THE ENGINEER

A Seven-Day Journal

The Iron and Steel Corporation of Great Britain

ON Thursday of last week, February 15th, the Iron and Steel Corporation of Great Britain became the sole stockholder of the eighty iron and steel companies specified in the third schedule of the Iron and Steel Act, 1949. On the following day the Corporation made a statement on recent discussions which it has had with the British Iron and Steel Federation. In the statement the Corporation announced that it had not been able to reach agreement with the Federation on arrangements to cover the next three months of the "interim period," during which a long-term organisation for the British steel industry was to be set up. The Federation's proposals, the statement indicated, were not acceptable to the Corporation and the Federation was so informed at a meeting between the two organisations on February 14th. It appears that the Corporation is anxious to be represented on the council and the executive committee of the Federation. It will be recalled that the Federation has offered the Corporation the services, in a consultative capacity, of the president and three other leading steelmakers. The view of the Corporation, it is understood, is that that offer does not go far enough, the hope having been expressed last week by Mr. S. J. L. Hardie, the chairman, that "at the appropriate time" the four additional members, whom the Minister of Supply is empowered to appoint to the Corporation, would come from within the steel industry.

Plans of Abandoned Coal Mines

ARRANGEMENTS have been made by the Ministry of Fuel and Power for the National Coal Board to hold the plans of abandoned mines and seams of coal which were deposited for preservation under the Coal Mines Act of 1911. So that these plans may be accessible to persons who have occasion to consult them, each division of the National Coal Board has been made responsible for holding the plans relating to the mines in the division. The transfer of the plans from the Ministry of Fuel and Power Mining Records Office at Buxton has been proceeding during the past twelve months and was recently completed. The addresses of the premises where the plans are stored and the officer to whom application to inspect plans should be made, will be supplied upon request to any of the divisional offices of the National Coal Board, or to H.M. Inspectors of Mines, or at the headquarters of the Board or the Ministry of Fuel and Power. Plans deposited under the Coal Mines Act of abandoned mines and seams of other minerals, such as shale, fireclay and stratified ironstone, and plans deposited under Section 14 of the Metalliferous Mines Regulation Act, 1872, have been transferred from Buxton to London. Applications to consult these should be addressed to the Officer-in-Charge, Mining Record Office, Ministry of Fuel and Power, King's Buildings, Dean Stanley Street, London, S.W.1.

Chamber of Shipping Annual Report

IN the recently issued annual report of the Chamber of Shipping three main points are stressed. They are the dislocation of shipping caused by tonnage diversions, the effect of Government bulk buying and taxation iniquities. The report deplores the constant discoveries of a "short position" by a Government buyer, which have such serious repercussions in the tonnage market. The sudden decision to import coal is instanced for the resulting demand for tramp tonnage, dislocating chartering and gravely affecting liner companies' commitments. The usefulness of the tramp ship, the report notes, lies in its flexibility, and the diverting of a large number of such vessels to make a long voyage in ballast in order to return with a specific cargo reduces their usefulness. The report criticises both the timing of the demand and the broadcasting of the intention to import, for, it claims, the Minister should have known that ships were fully employed and that freight rates would be forced up. The inability of bulk buyers and bulk sellers to agree on the price of meat has resulted in the complete stopping of meat cargoes from the Argentine; a position, the report continues, which has resulted in considerable losses to the shipping lines engaged in the trade. Expensive refrigerated ships have been idle or have been uneconomically employed carrying general cargo. It is recalled that two years ago the difficulty of maintaining the industry's working capital, when income and profits tax took most of the profits retained in the business, was stressed. The present level of taxation is reducing the power of the shipping companies to renew and maintain efficient fleets and the report claims that on the grounds of national security shipping should have special consideration because an up-to-date merchant marine is essential to survival.

Land Restoration After Iron Ore Working

THE Mineral Workings Bill published last week, provides for an Ironstone Restoration Fund, which will be used to restore to agriculture, as completely and quickly as possible, land worked for iron ore. Payments to this fund will be on the basis of a levy of 3d. for each ton of ironstone worked opencast after July 1st next in an area comprising the counties of Leicester, Northampton, Oxford, Rutland and Warwick and parts of Kesteven and Lindsey in Lincolnshire. Of this levy ironstone producers will be required to pay 1½d., the landowners 1½d., and the exchequer ¾d. Payments can be made out of the fund to meet the costs incurred by ironstone producers in levelling land and will be made only when the overburden is 35ft or more deep and the costs which will be met will be the excess over the average cost of levelling land with a 35ft overburden. Where the overburden is less than 35ft no payments will be made. Other purposes for which payments will be made out of the fund will be for costs incurred by landowners or local authorities in making land already worked suitable for agriculture or forestry and improving its general appearance; costs of managing or cultivating worked ironstone land by the Ministry of Agriculture and Fisheries or their lessees, and the cost of forestry work carried out by the Forestry Commission or landowners. It is estimated that the annual cost of the fund to the Exchequer will be £45,000. The Bill also contains clauses affecting the payment of development charges and the receipt of payments from the £300 million fund.

Underground Gasification of Coal

IN the House of Commons, on Monday last, Mr. R. Robinson asked the Minister of Fuel and Power whether he had now assessed the results of the experiments in the underground gasification of coal at Newman Spinney, near Chesterfield, and whether it was proposed to continue the experiments on a larger scale. The Minister, replying in a written affirmative, said that his Scientific Advisory Council had recommended an expansion of the work at Newman Spinney and further experimental work in other coalfields with differing geological characteristics. This work was being planned and the National Coal Board was actively co-operating in it. At a press conference on the same day, Dr. Roxbee-Cox, chief scientist of the Ministry of Fuel and Power, described the first trial system. Preparations were made by drilling two vertical boreholes 50ft apart, giving access to a third hole drilled almost horizontally in the coal, 75ft underground. This coal seam was ignited early in July last and it had been producing gas ever since. A second larger borehole had been prepared by similar methods ready for gasification this year. Difficulties had been created by horizontal drilling and, to overcome them, a system had been introduced by which high pressure air was applied through vertical boreholes reaching to below the top of the coal. The pressure slightly lifted the overlying coal strata and allowed air to pass through the coal between boreholes sunk 33ft apart. On this system gasification had been proceeding for four months. Up to date some £50,000 had been spent on experiments. Mr. C. A. Masterman, the Ministry's director of underground gasification, said that a square mile of coal 3ft thick could produce enough gas to generate at least 25,000kW for at least ten years.

Hyde Park Corner Improvement Scheme

PROPOSALS for improving the lay-out of Hyde Park Corner have recently been agreed in principle between the London County Council, the Westminster City Council and the Ministry of Transport. The construction of a new and larger traffic roundabout taking in a small part of Green Park at Hyde Park Corner and a narrow strip on the edge of the private grounds of Buckingham Palace is envisaged. In place of the existing islands and refuges there will be one central island, attractively designed, to which access may be provided by pedestrian subways. Wellington Arch will remain in its present position but the carriageway of the roundabout will be moved from the western to the eastern side of the gate. Existing traffic light signals will be abolished, as all traffic cuts will be eliminated; pedestrian subways may form part of the final scheme. The proposals form part of a comprehensive scheme, which includes the construction of a larger roundabout at Marble Arch and the provision of a boulevard between Marble Arch and Hyde Park Corner. Park Lane and the Ring Road inside Hyde Park will be converted into one-way roads with connections, so that together they will form a twin-carriageway road. When the scheme is complete vehicles will no longer pass through Apsley Gate but will gain access to the Park and the New Park Lane by way of a new street built through the gap left by bombing in the buildings east of Apsley House. There will be a subsidiary roundabout inside the Park just north of Apsley Gate. At Marble Arch islands will be provided to separate traffic entering the junction from the park and turning eastwards along Oxford Street from the traffic going westwards along Bayswater Road or northwards into Edgware Road. The processional route through Wellington Arch on Constitution Hill and Marble Arch will be maintained. These plans have been prepared jointly by the Ministry of Transport and the London County Council. The scheme is of a long-term character and it is not possible to say when a start will be made.

High-Powered "Mallet" Freight Locomotives

By E. C. POULTNEY, O.B.E., M.Inst.Loco.E.

No. II—(*Continued from page 212, February 16th*)

Dynamometer Car Tests

A SERIES of comprehensive tests with the railway company's dynamometer car has been carried out with the 2–6–6–6 "H-8" class locomotive, No. 1608, for the purpose of determining the performance on different divisions of the railway.

The trials were made between February and August, 1943, and consisted of runs over the Alleghany Sub-Division and the Northern Sub-Division as indicated below.

Clifton Forge, Va., to Hinton, W. Va., five single trains.

Hinton, W. Va., to Clifton Forge, Va., three single trains.

Hinton, W. Va., to Clifton Forge, Va., two double trains with class "H-7" "Mallet" 2–8–8–2 type pusher.

Hinton, W. Va., to Clifton Forge, Va., two double trains with class "H-8" "Mallet" 2–6–6–6 type pusher.

Russell, Ky., to Columbus, Ohio, four single trains.

Russell, Ky., to Columbus, Ohio, one double train with class "T–1" 2–10–4 type pusher over Limeville Bridge.

Preparation of Locomotive and Method of Test

A dynamometer car, used for all the tests, made it possible to obtain the mean and maximum drawbar pulls, the horsepower, foot-pounds of work done, and other data.

The measurement of water taken from the tender was obtained by the use of a water-indicating gauge operated by compressed air, and recorded at all times by a gauge fitted in the dynamometer car. To avoid inaccurate water levels due to surging of the water in the tank, it was found necessary to use a 4in water well located at the centre of gravity of the tank. To prevent any possibility of error the tank water was measured with a calibrated stick at each stop. No appreciable difference was found between the water-measuring stick and the gauge in the dynamometer car.

Determination of the Coal Consumption

The locomotive being equipped with a stoker, it was necessary to find means for calibrating the stoker and recording the amount of coal fired. This was accomplished by measuring the amount of coal delivered by the stoker screw and electrically recording this in the dynamometer car. To ascertain the accuracy of this method for obtaining the coal fired a standard coal bucket of 200 lb capacity was installed on the engine. After weighing 18,400 lb of coal and comparing it with the stoker revolution method, the two weights were found to be approximately the same. The accuracy of such a method depends entirely on three factors, namely, accurate calibration, ascertaining that the stoker screw was full at all times during the test and adjustment for weight of coal per cubic foot during each test run. All these were checked closely over the test period.

Determination of the Water Consumption

The locomotives forming the subject of these trials are fitted with high-temperature feed-water heating equipment. The apparatus used is the Worthington type "S," which is an open type heater, the exhaust steam being condensed in the mixing chamber, where it meets incoming cold water from the tender tank. Condensate, together with the heated tank water, together form the boiler feed water supply. To ascertain the total feed water delivered to the boiler that part composed of the condensate must be determined. On this point, the Chief Mechanical Officer, C. and O. Railway, advises that the practice is to take the condensate as being equal to 1 per cent of the total water for each difference of 11 deg. between the average tank temperature and the average feed water temperature. The actual amount of water pumped from the tender tank to the mixing chamber of the feed heater is obtained as already described.

The consumption of coal and water per horsepower developed at the tender drawbar was based on the working time. The method employed for obtaining the coal fired enabled the amount used when actually working to be determined and the corresponding quantity of water evaporated during the same time being computed from the water-coal ratio.

On all the tests the locomotive was fitted with a double chimney, the front exhaust nozzle having a diameter of 7⅛in and the back nozzle being 7 5/16in diameter. A ⅛in square cross bridge was fitted to both nozzles.

Purpose of the Tests

The tests with locomotive No. 1608 were made to establish the performance from the point of view of hauling capacity, power output, fuel and water consumptions and efficiency. Boiler performance was also determined with regard to rate of firing and evaporation, and in connection with this the feed heater performance was obtained and the draught in relation to exhaust steam pressures and temperatures. Overall efficiency was calculated on the basis of the calorific value in B.Th.U. per pound of dry coal.

Location

The trials made on the Alleghany Sub-Division from Clifton Forge, Va., to Hinton, W. Va., and return, covered a distance of about 80 miles. This is a heavy grade division and between these points the summit is reached at Alleghany, Va., 30 miles from Clifton Forge, westbound, and about 50 miles from Hinton, W., eastbound. In heavy coal traffic empties are worked westbound from Clifton Forge, and loaded trains in the reverse direction from Hinton, W. The principal grade between Clifton Forge and Hinton, W., is a rising gradient extending for about 10 miles at the rate of 1·14 per cent, 1 in 88, with a further mile of grades varying from 1·0 per cent, 1 in 100, to 1·38 per cent, 1 in 72. The line rises for the greater part of the distance up to Alleghany. The ruling grade eastbound between Hinton, W., and Clifton Forge, covers a distance of 12·5 miles, of which 7·375 miles is over a rising grade of 0·57 per cent, 1 in 175, and the remainder on an upgrade of 0·56 per cent, equal to 1 in 178.

On the Northern Sub-Division between Russell, Ky., and Columbus, Ohio, 109·9 miles, the principal grade extends for 17·25 miles, of which 1·25 miles are on rising gradients of 0·68 and 0·70 per cent, 1 in 147, and 1 in 143 on the approach to and over Limeville Bridge. This is the ruling grade on the division and commences about 15 miles from Russell. The balance of the gradient extending for 16 miles varies from level to 0·20 per cent, 1 in 500. This grade governs the weight of trains handled over the division because it is not convenient to make

Table I.—*Chesapeake and Ohio Railway.—Dynamometer Car Tests, Class "H-8," Locomotive No. 1608.—Locomotive Performance.—Northern Sub-Division and Alleghany Sub-Division*

Location	Russell, Ky., to Columbus, Ohio			Clifton Forge, Va., to Alleghany, Va.		Hinton, W. Va., to Alleghany, Va.			
Test number	100	102	104	7	9	8	18	6	14
Tonnage, actual (2000 lb)	12,466	13,109	14,075	2,982	2,979	5,826	5,760	11,606	11,623
Cars, total	162	162	162	130	132	70	70	144	141
Loads	160	160	160	0	0	68	68	142	139
Empties	0	0	0	128	130	0	0	0	0
Distance, miles	109·91	109·76	109·88	29·37	29·33	49·75	49·47	49·65	49·89
Distance, working	105·42	100·49	101·46	29·00	28·71	48·87	49·47	48·82	49·03
Time, total, h. min.	4 36½	4 11	4 21	1 19	1 23	1 43	1 48	1 59	2 09
Time, working, h. min.	3 34	3 18	3 30	1 18	1 22	1 41	1 48	1 55	1 55
Speed, m.p.h., working	29·56	30·45	28·87	22·31	21·01	29·03	27·48	25·47	25·66
Coal, total, lb	43,751	46,094	49,558	18,747	16,036	20,464	20,148	25,946	20,520
Coal, working, lb	43,145	44,843	48,424	18,697	15,966	20,345	20,148	25,838	20,404
Water, total, gallons, U.S.	37,352	39,356	42,859	13,879	14,430	18,201	18,347	22,883	20,288
Water/coal, lb	7·11	7·12	7·21	7·21	6·96	7·41	7·59	7·35	8·24
Firing rate	89·62	100·66	102·48	106·54	86·57	89·53	82·91	99·86	78·86
Steam pressure, p.s.i., average	259	259·8	260	258·75	260·0	260	259	257	260
Average d.b.h.p.	4,129	4,656	4,762	3,706	3,460	4,015	3,430	4,174	3,574
Coal, lb per 1000 G.T.M.	31·93	32·03	32·03	214·05	184·16	70·6	70·71	93·05	70·78
Coal, lb per d.b.h.p.-hr.	2·93	2·92	2·91	3·88	3·38	3·01	3·26	3·23	2·94
Water, lb per d.b.h.p.-hr.	20·84	20·77	20·93	25·18	24·37	22·31	24·73	23·74	24·54
Thermal efficiency, per cent	6·36	6·40	6·47	4·95	5·34	6·05	5·89	5·56	6·09
Millions ft-lb of work	29,160	30,420	33,000	9,540	9,360	13,380	12,240	15,840	13,560
Cut-off, maximum, average, min., per cent	73, 56, 36	82, 44, 59	79, 58, 40	82, 70, 53	81, 69, 52	73, 63, 49	74, 60, 46	82, 68, 49	82, 66, 47

a practice of providing a pusher at this point.

Continuing forward from Columbus, Ohio, to Toledo, Ohio, while the line is generally favourable for the movement of heavy loaded coal trains operating from the concentration yards at Russell, through to Toledo, Ohio, there is a long grade extending for 16 miles just after leaving Columbus. Over this distance the maximum gradient is 0·50 per cent, 1 in 200, and because of this heavy through trains are double headed from the start at Columbus, Ohio, up to the sixteenth mile post at which point the assistant engine is cut off. From the sixteenth to the eighty-first mile post the line undulates over the entire distance, the maximum grade being 0·28 per cent or 1 in 350. No difficulty is met with in working over this section because the momentum of the train largely reduces the pull required on the rising gradients. After passing the eighty-first mile post the line falls for practically the remainder of the 120·6 miles from Columbus to the freight yards at Toledo.

Locomotive No. 1608 Test Results

The average results obtained during all test runs with engine No. 1608 are summarised herewith.

Alleghany Sub-Division.—The average single train eastbound Hinton, W. Va., to Northern Sub-Division the water rate per drawbar horsepower averaged 22·34 for four loaded trips, the maximum per train being 25·95 and the minimum 20·77 lb.

The test runs on the Northern Sub-Division referred to in this summary cover two test runs from Russell through to Columbus, and two runs from Russell to Robbins, Ohio, the latter being a relatively short run of 39 miles.

The average results also refer only to tests without pusher assistance over the ruling grade at Limeville Bridge. The amount of steam furnished by the boiler for all test runs over both divisions of the line was never a factor governing the amount of tonnage hauled. In all instances the locomotive steamed freely.

The test results showed that the locomotive frequently developed a sustained drawbar horsepower of 6700 to 6900 at a speed of 42 and 46 m.p.h. The highest instantaneous horsepower recorded at the drawbar was 7498 at a speed of 46 m.p.h.

Detailed Particulars of Test Results

The foregoing summary gives in a general manner some of the more important information obtained during the test runs. More detailed data are given by Tables I and II, which relate to the trials made between Russell, Ky., and Columbus, Ohio, tests sented by the official report and will, it is thought, give a good general picture of the locomotive performance. The results in rather more detail are shown in Table II, drawn up to indicate more particularly the boiler performance.

Test 102 with a heavy train of 13,109 handled between Russell and Columbus, at a mean working speed of 30·45 m.p.h., indicates an excellent performance when an average of 4656 h.p. was maintained for 3 h 18 min. The water evaporated during this time was at the rate of 96,705 lb per hour, or 13·3 lb per square foot of evaporative heating surface per hour. The coal and water rates at this high rate of working were respectively 2·92 lb and 20·77 lb per horsepower-hour and the thermal efficiency 6·4 per cent. To move a train of 160 loaded cars making, with two other cars, a total of 13,109 tons, at over 30 m.p.h., is a fine performance, even though the line is with the exception of the Limeville grade favourable for the movement of heavy trains.

During this trip a maximum of 7087 h.p. was recorded and the maximum sustained horsepower was 6941, the mean being 4656 as already mentioned.

Alleghany Sub-Division Tests

The working results shown for tests 7 and 9 indicated the locomotive performance on a

Table II.—*Chesapeake and Ohio Railway.—Dynamometer Car Tests, Class "H-8," Locomotive No.* 1608.—*Boiler Performance, Coal and Water Consumptions, Evaporation and Steam Conditions*

Test number	100	102	104	7	9	8	18	6	14
Coal, total, lb	43,751	46,094	49,558	18,747	16,036	20,464	20,148	25,946	20,520
Coal, working, per hr./lb	12,116·6	13,610·2	13,835·5	14,395·2	11,700·2	12,404·4	11,503·4	13,504·0	10,694·8
Water, tank, gallons	35,047	36,781	39,671	13,225	12,583	16,640	16,742	20,668	18,519
Water, total, gallons	37,352	39,356	42,859	13,879	14,430	18,201	18,347	22,883	20,288
Water, total per hr./lb	86,048·3	96,705·1	99,669·6	93,316·0	83,310·2	89,574·6	84,823·9	99,090·7	87,705·9
Coal, lb per sq ft of grate area, per hour	89·62	100·66	102·48	106·54	86·57	89·53	82·91	99·86	78·86
Water tank temperature, deg. Fah.	86·9	83·4	83·03	80·0	75·4	90·2	83·1	81·05	84·14
Water feed temperature, deg. Fah.	229·6	230·1	232·6	228·5	226·5	223·7	225·4	231·8	225·3
Water/coal, lb	7·11	7·12	7·21	7·21	6·96	7·41	7·59	7·35	8·24
Water/evaporative heating surface, sq ft, lb per hour	11·89	13·3	13·75	12·88	11·5	12·36	11·7	13·65	12·10
Steam, boiler, p.s.i., average	259·0	259·8	260·0	258·7	260·0	260·0	259·2	257·0	260·0
Steam, front engine, p.s.i.	240·0	240·5	240·6	239·6	241·8	243·2	241·8	239·4	244·2
Steam, rear engine, p.s.i.	244·0	244·1	245·1	243·9	245·6	247·0	246·7	243·1	248·8
Steam temperature, front engine, deg. Fah.	697·4	699	707·1	701·2	703·3	700·7	699·0	709·6	684·3
Steam temperature, rear engine, deg. Fah.	715·5	714·1	724·3	721·3	728·3	726·1	722·0	730·6	707·8
Steam, back pressure, front engine	11·2	11·34	12·3	11·4	11·9	10·12	9·9	11·49	9·38
Steam, back pressure, rear engine	14·7	15·28	16·0	14·4	14·8	13·3	12·7	14·53	12·41
Throttle opening	Full	Full	Full	Full	Full	Full	Full	Full	Full
Calorific value coal, dry, B.Th.U. per lb	13,657	13,623	13,542	13,246	14,114	13,967	13,250	14,166	14,029

Alleghany, was 5790 tons, 72 cars, and the average double train with pusher assistance 11,569 tons or 143 cars. The average single train westbound Clifton Forge, Va., to Alleghany, Va., was 2986 tons or 131 cars.

The mean running time from Hinton, W. to Alleghany for a single train was 1 h 46·7 min with a running speed of 27·89 miles per hour. From Clifton Forge to Alleghany the mean running time was 1 h 19 min, equal to a running time speed of 22·25 m.p.h. The average running time from Hinton, W. to Alleghany, with pusher assistance, was 1 h 57 min, or a mean running speed of 26·12 m.p.h.

Northern Sub-Division.—The average running time from Russell, Ky., to Columbus, Ohio, was 4 h 23 min, with a running speed of 29 m.p.h.

The evaporative capacity of the boiler for seventeen test trips averaged 7·37 lb of water per pound of coal. The maximum evaporation per train was 8·24 lb. The coal per 1000 gross ton miles for seven loaded trips on the Alleghany Sub-Division averaged 77·11 lb, and on the Northern Sub-Division the coal per 1000 gross ton miles for four loaded trips averaged 40·68 lb.

On the Alleghany Sub-Division the water per drawbar horsepower averaged 23·76 lb for seven loaded trips, with a maximum of 24·73 and a minimum of 22·31 lb. On the 100, 102 and 104 and both eastbound and westbound between Clifton Forge, Va., and Hinton, W. Va. Between these points the actual tests were made from Clifton Forge up to Alleghany in the westbound direction, handling trains of empty cars, and eastbound from Hinton, W. up to Alleghany, moving heavy loaded cars of coal in single and double trains, the latter in each instance with an assistant engine in the rear. The runs from Russell to Columbus were made with loaded trains of coal moving westbound from Russell through to Toledo, Ohio. Two further tests were made over this, the Northern Sub-Division. These, however, extended only as far as Robbins, Ohio, 39 miles away from Russell. The performance on these trips was generally very similar to the results given for tests 100, 102 and 104.

The tests on the Alleghany Sub-Division, tests 7 and 9, westbound, and 8, 18, 6, and 14, eastbound, some results of which are given, are representative of the locomotive performance over these divisions. Tests 6 and 14 with heavy loaded double trains were made with pusher assistance in the case of test 6, a class "H–7" simple "Mallet" being used, and for run 14 a class "H–8," the same as that forming the subject of these trials. The test results given in Table I give the more important particulars collected from the very extensive information pre-heavy grade division. The actual mean powers developed at the tender drawbar are comparatively low and so also are the average speeds, but the mean pulls exerted will be higher, as indicated by the longer rates of cut-off which for tests 7 and 9 averaged 70 and 69 per cent, while for test 102, from Russell to Columbus, the mean cut-off was 44 per cent.

The tests 6 and 14 made from Hinton, W. to Alleghany are interesting because the results show how the working of the test engine was influenced by the capacity of the pusher. For instance, test 6 was made with the older "Mallet" type engine, class "H-7," having a rather lower rated tractive force than the new class "H-8" and relatively less boiler power. With the older engine the test locomotive worked hard with a rate of firing of 99·86 lb of coal per square foot of grate area per hour and developed a mean horsepower of 4174. When, however, for test 14 a class "H-8" "Mallet" was provided of the same class and equal to the test engine in capacity, the test engine had to do much less work indicated both by the lesser rate of firing and the lower mean power developed. It will be noted that for practically equal train weights and average speeds the average horsepower for test 14 was 14 per cent less than for the test 6 when the pusher was a class "H-7" engine. During the Alleghany Sub-Division tests on east-

bound run 14 with a train of 139 loaded cars using a class "H-8" pusher, the train was stopped by signal on a rising grade of 0·57 per cent, 1 in 175. A light rain had just started, making the rail conditions poor for starting the train, the whole of which was standing to the grade. However, after taking up the slack twice, the train was started with a corrected drawbar pull of 113,700 lb. No slips occurred and after 9 min the train was moving at 12 m.p.h. and 18 m.p.h. was reached in a distance of 2·5 miles.

The Magnetic Fluid Clutch*

By S. F. BLUNDEN

A NOVEL form of clutch was developed in 1948 by J. Rabinow, chief of the Ordnance Mechanics Section, National Bureau of Standards, U.S.A., and subsequently patented by him. The clutch comprises two concentric members with the space between them filled with a fluid mixture of iron particles in oil. Under the action of a magnetic field the mixture seemingly solidifies, and torque can be transmitted through the mixture in this condition. This article describes one such clutch made at the M.O.S. Radar Research and Development Establishment, Malvern, Worcestershire; its construction and the results of certain tests are given, together with an appreciation of its possibilities and shortcomings. It promises to have possibilities in the servo field after certain present difficulties have been overcome.

Description

It was decided to make a magnetic fluid clutch at R.R.D.E. in order to establish the technique of construction and to gain first-hand experience of its performance, with a particular view to predicting its suitability as a servo device. Two such clutches were on show at the Physical Society's exhibition last year. There are several forms which such a clutch may take, but those made at R.R.D.E. have the form shown in Fig. 1 and consist of

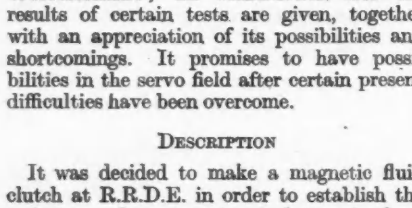

FIG. 1—SIMPLIFIED SECTION OF CLUTCH

two cylindrical concentric members, of which one, the input member, forms the outer case and includes a core containing a coil, whilst the other, the output, is merely a light mild steel shell. The annular space between the two members is almost filled with a fluid mixture of fine iron powder and oil; a small air space is left to allow for thermal expansion of the mixture.

When a magnetic flux passes through such a mixture of iron powder and oil it seemingly solidifies into a compact mass containing both iron and oil; there is no indication of any separation of the iron particles from the mixture on account of the magnetic field. Resistance is offered to the movement of any object, whether magnetic or not, embedded in this near-solid mixture, even though no deformation of the mixture takes place. When the magnetic flux is removed the mixture almost instantaneously returns to its original liquid condition. It is upon this phenomenon that the clutch depends for its action. When the clutch coil is energised a magnetic flux path is set up as shown dotted in Fig. 1, and the "magnetic fluid" stiffens into a compact mass where the flux crosses the gaps between the members. Since the output member is embedded in this compacted mass, resistance is offered to its motion relative to the input member. Torque can therefore be transmitted through the clutch.

The first model constructed at R.R.D.E. had an outside diameter of 3in and an overall length of about 3½in; the diameter of the output member was 2in and its effective length 1½in. The radial gaps between members were $\frac{1}{16}$in in length. With this clutch a torque of 125 oz-in could be transmitted with a coil input of 12W; this corresponds to about ½ h.p. at 1000 r.p.m.—the speed at which the clutch was used. This conversion ratio, i.e., the ratio of watts equivalent of the mechanical power transmitted to watts input to the coil is not as high as may be expected from this type of clutch. The reason for this is that the design was deliberately arranged so that, for study purposes, magnetic saturation should take place in two definite parts of the flux path. A second clutch has been made subsequently, which, at the same speed, will transmit 1 h.p. with a coil input of 9W—a more satisfactory conversion ratio.

The design chosen for the R.R.D.E. models is only one of several that could be adopted; multiple-plate types are also possible, in which the members consist of a number of discs, alternately coupled to the input and output shafts. In this design, if a large number of discs are used, the flux has to traverse a correspondingly large number of gaps in series, so that a larger magneto-motive force is required. It is also possible to use a stationary coil wound round the outside of the clutch, which obviates the use of slip rings. Of these alternatives it was considered that the form shown in Fig. 1 would be the most efficient with respect to conversion ratio.

The tests described below were all made upon the ½ h.p. clutch; only a few have as yet been made upon the larger model. These tests were aimed at determining the torque values transmitted under various conditions of excitation and slip. The effect of the iron proportion in the magnetic fluid has been studied and efforts made to discover the most suitable type of oil to be used. Attempts have also been made to discover any hysteresis effects, and the response of the clutch to alternating current has been investigated. The results of these experiments are described below.

Performance Using Continuous Excitation

The test rig used for most of these experiments is shown in Fig. 2 and comprised a ⅓ h.p. synchronous motor connected by gearing to the input of the clutch, together with a band brake dynamometer flexibly coupled to the output member. For most of the tests the clutch was run at 1000 r.p.m. and, as a result of certain experiments described later, a magnetic medium of 5 parts by weight of iron powder to 1 part of oil was chosen as the preferred mixture.

One feature of this type of clutch is that when slip occurs by excessive loading of the output member, its onset is entirely snatch-free, since the coefficients of static and dynamic friction between the solidified mixture and the clutch members appear to be identical. Indeed, the commencement of slip is so insidious that the actual torque at which it begins is very indeterminate. Fig. 3 shows the curve connecting output speed with output torque at various excitations, and from these curves it will be appreciated that figures relating output torque to coil excitation are much more reliable if given at a definite degree of slip, e.g., 1 per cent or 100 per cent, rather than at zero slip. For many applications this extremely smooth onset of slippage can be regarded as a virtue, but it must be guarded against by designers who plan to use the clutch as a dog clutch, i.e., under conditions which make positional creep intolerable. It is not surprising that if the clutches are run with prolonged periods of slip considerable heating will occur. Efficient means of dissipating this heat must be included in any design, and indeed the rating of a particular clutch which is intended for operation under slipping conditions is governed rather by the heat which it can dissipate than by the current-carrying capacity of the coil.

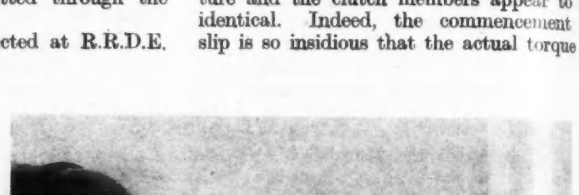

FIG. 2—TEST RIG

Typical torque-excitation curves are shown in Fig. 4 for slip values of 0 per cent, 1 per cent and 100 per cent. From these it can be seen that the torque response is almost a linear function of current. Tests have been performed to discover whether any hysteresis effects occur when the excitation current is altered on increasing and decreasing scales, but within the limits of experimental error no such effect could be detected. It was

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found with the clutch tested that, provided adequate precautions were taken to remove the heat generated, the clutch would run in a stable manner up to about 20 per cent slip; this can be seen from the curves in Fig. 3.

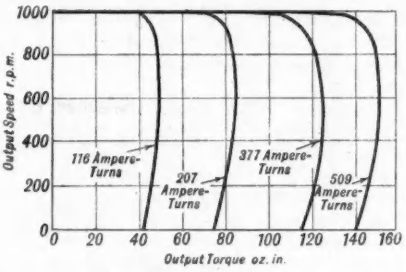
A non-magnetic output member was also tried in place of the mild steel shell shown in Fig. 1. This resulted in a torque reduction of about 40 per cent for corresponding coil excitations; it must be borne in mind, however, that the length of the high-reluctance portions of the magnetic circuit had been increased by this alteration. An attempt was made to deduce the flux in the gap in the two cases, and it was found that for similar flux conditions the same torque was transmitted. This seems to indicate that the torque is set up solely by frictional forces, rather than by any magnetic attraction between the two members.

A series of experiments have been conducted to discover the effect of varying the proportions of iron and oil in the mixture. These proportions have at least two important bearings upon the performance of any particular clutch. First, as may be expected, more torque can be transmitted with greater iron proportions for the same excitation. The other consideration concerns the torque set up between the members by the viscous drag of the magnetic mixture even with no current in the coil; this drag can be reduced but never entirely eliminated. With greater iron proportions in the mixture this drag increases at a very considerable rate. It was noted that, with the small clutch in question, the difference between the drag torque and that transmitted at some finite excitation was almost the same for any iron to oil proportion between 3 : 1 and 10 : 1 by weight. Thus, although the torque transmitted for a given excitation by a 10 : 1 mixture was much higher than that for a 3 : 1 mixture, the drag torque at zero excitation was similarly increased so that the difference between the two was much the same in each case.

Using a mixture of less iron than a 3 : 1 proportion by weight to that of oil, very long time lags between the build-up of torque and the application of current are introduced. For example, with a 1 : 1 mixture, the torque transmitted was still increasing about five minutes after switching on the coil current. Above a 7 : 1 ratio the mixture becomes very thick indeed, and the resultant drag at zero excitation is so great that very considerable heat is generated if the output is locked against rotation. A compromise has therefore to be adopted depending entirely upon the use to which the clutch is to be put. For the servo work envisaged at R.R.D.E. the preferred mixture is a 5 : 1 proportion by weight of iron to oil, this giving the best on-off ratio of torque. From Fig. 4 it is seen that for this clutch under test the drag torque at zero excitation was 8 oz-in, whilst at the full rated excitation of 750A turns it was 125 oz-in—an on-off ratio of about 16 : 1. The corresponding value for the 1 h.p. clutch previously mentioned was found to be about 20 : 1 when using the same mixture.

Another interesting result arising from varying the iron proportion is that the maximum percentage slip at which the clutch will run in a stable manner is reduced as the mixture becomes thicker. Thus, whilst with a 5 : 1 mixture this figure, as previously mentioned, was about 20 per cent, with a 10 : 1 mixture it was reduced to about 3 per cent. With this latter mixture therefore, the clutch operated under fully locked or fully slipping conditions with practically no intermediate stage.

Efforts have been made to analyse the zero-excitation drag torque into its component parts. The ½ h.p. clutch was run (*a*) with no mixture in it at all, (*b*) filled with clear oil only, (*c*) filled with the iron-oil mixture with the whole assembly carefully demagnetised, and (*d*) as for (*c*) but after having passed maximum current through the coil and then switched off again. Of these tests, the first obviously indicates the drag due to the oil seals and bearings, and was found to be in the order of 2 oz-in. The difference between (*b*) and (*a*) shows the drag due to the clear oil, and that between (*c*) and (*a*) shows the drag due to the mixture. Here, the oil alone



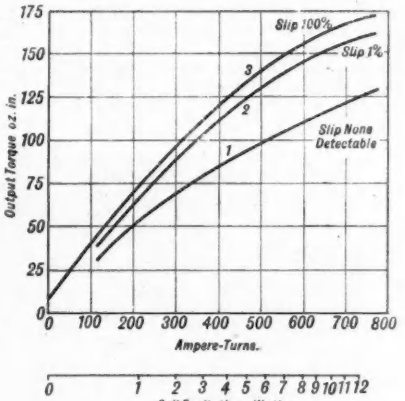
Clutch conditions
Magnetic mixture, five parts "ME" iron powder to one part transformer oil B by weight.
Input speed, 1000 r.p.m.

Fig. 3—Relation Between Output Torque and Output Speed

produced 1 oz-in drag, whereas the demagnetised 5 : 1 mixture produced 4 oz-in. The drag torque due to residual magnetism, given by the difference between (*d*) and (*c*), was 2 oz-in, and the total under normal conditions was therefore 8 oz-in. This figure, however, is varied considerably: (*a*) by different iron proportions, (*b*) by the viscosity of the oil used, and (*c*) by the temperature of the mixture.

Performance Using Alternating Excitation

Various authorities quote different types of results to demonstrate that these clutches respond rapidly to changes of magnetising current. The method chosen to test this



Clutch conditions
Magnetic mixture, five parts "ME" iron powder to one part transformer oil B by weight.
Input speed, 1000 r.p.m.

Fig. 4—Relation Between Output Torque and Coil Excitation

feature was that of applying approximately sinusoidal voltages to the clutch coil; the frequency range chosen was from nearly zero to 50 c/s, and the magnitude was adjusted in each instance to give a peak current equal to the d.c. current needed to make available the full-load torque. The output member was locked against rotation and the resultant pulsating torque was displayed on a double-beam C.R.O., the second trace being made to represent the current wave. These torque waves had some resemblance to rectified sine waves, and their amplitude and phase relative to the current waves were determined from the C.R.O. traces. Even at 50 c/s appreciable torque was still transmitted roughly one-quarter of that obtained using d.c.; this result is unexpectedly good. The phase angle between torque and current was about 80 deg. at 50 c/s and about 35 deg. at 10 c/s.

Fluid Mixture

The iron powder used in most of the tests at R.R.D.E. was carbonyl iron, grade ME. This is a mechanically hard form of iron, with a particle size of 5 microns, the particles being mainly spherical in form. A grade MC has also been tried in the clutch, but with almost identical results as with the grade ME. The MC type has the same particle size and shape, but is mechanically soft and has a much higher permeability when dry and compressed. The effect of its higher permeability, however, is eliminated when mixed with the oil, presumably because of the relatively large gaps between the particles filled with a medium whose permeability is near unity. Any advantages from the wear point of view of using the softer powder are practically non-existent, for even with the hard type wear on the faces of the members is undetectable after long periods of use. No other powders have been tried as yet, but it is planned to do so in the near future.

Obviously, from the point of view of a vehicle for the suspension of the iron powder, almost any liquid would be suitable, although oils are preferred because of the lubrication they provide between the particles. From other considerations, however, the choice of a suitable fluid is rather restricted. As previously mentioned, considerable heat is generated under slipping conditions; the oil chosen must therefore have high flash and boiling points. It must also be entirely free from any substance which will react chemically with the iron powder, and in this respect sulphur is the most likely cause of trouble. Again, in order to reduce the zero excitation drag as far as possible, the viscosity of the oil must be very low, and its variation with temperature a minimum. Transformer oil B has been used successfully at R.R.D.E., but the use of Silicone Fluid of about 20 centistokes viscosity is envisaged for the larger clutch on account of the greater heating effects, especially since pan-climatic operation is desired.

Two of the principal objections to the magnetic fluid clutch are those of static and centrifugal sludging of the powder. If the mixture is left idle for a few days settlement of the powder takes place and a thick sludge is formed, which is not easily broken up. This is a grave objection in cases where instant action at any moment is desired. Certain wetting agents have been tried, such as polyethylene glycol oleate, but no outstanding measure of success has yet been achieved. Centrifugal sludging occurs when the clutch is left running in a non-excited condition; the particles are flung to the greatest radius possible and form a solid mass linking the two members. This is particularly serious where a single clutch is being used. In the case of a twin-opposed servo system embodying two such clutches acting as a differential the difficulty is much less acute, since the energised clutch drives the output member of the second clutch in the direction opposite to its normal rotation. Thus a violent stirring action is set up and the powder is not allowed to compact together. Under these conditions no trouble has been found up to radial accelerations of about 60 g., but it is feared that at 120 g. such effects might begin to be serious. Further work on this subject is being under-

taken, but is not yet complete. A possible solution to the problem of static sludging may lie in the production of a thixotropic mixture, i.e., a mixture which gels under static conditions but which liquefies when a shearing action takes place within it. Such a mixture will support the iron powder in suspension for very long periods, but it is anticipated that it will form no palliative to the centrifugal sludging effects. Tests to determine whether this is so and to discover the maximum operating speed are also planned.

In order to facilitate magnetic flux calculations the permeability of various liquid mixtures has been measured. The apparatus used consisted of a square framework of bakelite tubes, which could be filled with the mixture under test. On each arm of this framework were mounted two flux coils with a search coil between them. Change in flux through the mixture was recorded on a Grassot-type flux meter connected to the search coils. The results showed that the permeability of mixtures ranging from a 1 : 1 to a 10 : 1 ratio of iron to oil varied linearly from about 2 to about 8 at a flux density of 2000 lines per square centimetre. The permeability of a 5 : 1 mixture varied from 6 to 4·5 over a flux density range of 1000 to 4000 lines per square centimetre.

Conclusions

This form of clutch has interesting possibilities, especially in the servo field, but before it is of any commercial use careful consideration will have to be paid to the difficulties outlined above. The many parameters that can be varied allow for a very wide range of uses, and the design of any particular clutch will depend entirely upon the duty for which it is intended, e.g., in those cases in which drag is unimportant it may be advantageous to use a mixture rich in iron; in other cases, in which a long build-up time for torque is required or tolerable, then an iron-poor mixture might be the best. For servo work a high ratio between torque and inertia is an advantage; in this case care must be taken to keep the inertia of the output member as low as possible. Again, torque can be increased for a given excitation by reducing the standard gap between members below $\frac{1}{16}$in, but this will be at the expense of increased drag torque in the non-excited condition.

The chief virtues of the clutch appear to lie (*a*) in its smooth transition to the locked solid condition (this, unfortunately, is not applicable to the case of a twin-opposed servo intended to slip continuously), and (*b*) its rapid response to changes in coil excitation.

Sealing of the clutch against egress of the mixture is not easy. Normal synthetic rubber oil seals appear to give fair protection to the bearings supporting the output member, but internal pressures developed by the expansion and vaporisation of the oil inside the clutch under working conditions will often force the oil through any joints in the outer casing or into the coil chamber. This must be borne in mind by any prospective designer and suitable provision made.

Acknowledgments

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this paper.

A 10-Ton Mobile Crane

AN interesting addition to the range of full-circle slewing mobile cranes made by R. H. Neal and Co., Ltd., Plant House, Ealing, London, W.5, is a new 10-ton unit illustrated on this page. This crane is designed to lift, without the use of outriggers, a load up to 10 tons and travel with the load under its own power. It can be fitted with a 30ft swan-neck jib or lattice jibs, 45ft, 60ft or 75ft long. The swan-neck jib is used for handling the maximum load of 10 tons at 11ft 6in radius and lattice jibs are fitted when the crane is required for raising lighter loads at greater radii. With a 45ft lattice jib the crane can lift up to 6 tons to 43ft at 16ft radius; with a 60ft lattice jib up to 4 tons can be raised to 57ft at 21ft radius, and with a 75ft lattice jib up to 2½ tons can be raised to 71ft at 26ft radius. A second independently operated hoist barrel forming part of the crane machinery can be used to adapt the unit for handling a double-rope grab with a total weight loaded of 3 tons at 26ft radius. The crane has three road speeds of 1, 3 and 5½ miles an hour, and its minimum turning radius is 25ft. In full working order it weighs about 26 tons.

The chassis of this crane consists of a rigid fabricated steel box frame built up of ¾in and 1in plates welded together and heavily braced. A cast steel axle member bolted to the frame carries the front wheel stub axles on 3½in diameter nickel-steel kingpins. These pins are supported in double roller bearings at the top and bottom, and adjustable self-aligning ball-thrust bearings take the vertical loads. Twin front-wheel assemblies are carried by Timken tapered roller bearings on the stub axles and each of the four front wheels is independently mounted to avoid scrubbing effect on the tyres during steering movements. All eight road wheels of the crane are fitted with reinforced extra-heavy Dunlop 14·00–20 tyres.

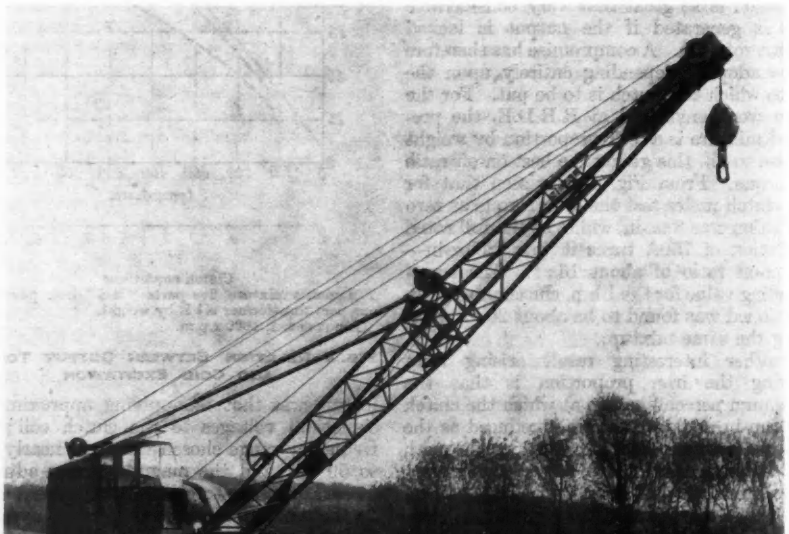
A fixed 8in diameter rear axle mounted in bored bosses in the frame is designed to carry only the bending loads and is not subjected to any torsional loading. The rear-axle assemblies are mounted on cast steel hubs carried by Timken tapered roller bearings on the axle. The final drive gears and brake drums are bolted directly on these hubs. Specially designed brakes which are fitted to the rear wheels have their back plates, which carry the shoes and take the braking torque, bolted to the chassis frame. In addition to the 20in diameter double-shoe rear wheel brakes a 16in brake is also fitted on a countershaft at each side through which the final drive is transmitted to the wheel hub assemblies. These transmission brakes are applied through the crane driver's pedal and the wheel brakes by a lever, at his right hand.

From the machinery in the superstructure drive is transmitted to the rear wheels through a vertical centre shaft, bevel reduction gearing and spur gears, and a duplex automatically reversing free-wheel. This free-wheel mechanism provides the necessary differential action between the rear wheels. As already mentioned, each of the rear wheels is driven by a countershaft fitted with a brake, and the final drive from these shafts to the wheel hubs is taken through heavy steel pinions and gears. The brake rods and steering rods pass through the centre- or king-post of the superstructure and are so arranged that their operation is not affected by rotation of the superstructure.

The frame of the superstructure is of fabricated steel construction, and it is carried on five large tapered hook-rollers on the slewing ring. These rollers are so positioned that two take the downward load at the front of the superstructure, one carries the upward load at the rear, and the other two, arranged diametrically opposite one another at the sides, act as stabilisers. A heavy forged steel king post fitted with phosphor-bronze bearings at the centre of the superstructure centralises it on the undercarriage. Tapered paths for the support rollers are machined in the cast steel slewing ring on which the superstructure rotates, and gear teeth are machined round its upper periphery.

A 60 h.p. diesel engine, which forms the power unit of the crane, is situated at the rear of the superstructure, and, through a plate clutch, drives the shaft of the first pinion in a primary transmission gear case set along the left-hand side of the revolving frame. A train of helical gears in this case drives the slewing and derricking shaft, the main transmission shaft and the hoist countershaft. These totally enclosed gears run in an oil bath and all of their shafts are mounted on ball bearings. The first shaft carries the slewing clutches and bevel pinions. On the second shaft are mounted the hoist clutch for the main barrel, the clutches and bevel pinions for travelling and the hoist clutch for the auxiliary barrel. It may be mentioned here that the first pinion in the transmission gears has a hollow shaft through which is taken a drive to an air compressor, used for tyre inflation, and the engine radiator fan drive.

The hoist clutch on the main transmission



10-Ton Mobile Crane

shaft drives the countershaft through a first reduction. A spur pinion on this countershaft drives a gear ring bolted to the hoist barrel. A hoist brake on the countershaft is fitted with one of the firm's "Uni-Directional" friction clutches which makes it possible to operate the hoisting motion without releasing the main brake. A large band-type main brake incorporates a spring mechanism designed to give complete control of the lowering speed at all times. When the machine is being used only as a lifting crane the clutch for the auxiliary barrel is geared to the main barrel to make possible high-speed lowering of the empty hook. This auxiliary hoist barrel is situated at the front of the revolving frame and has its own independent brake, which acts directly on the barrel. With a four-part rope 10-ton loads can be hoisted at 30ft per minute, with a two-part rope 6-ton loads can be raised at 60ft per minute, and with a single rope 3-ton loads can be raised at 120ft per minute.

Plate-type reversing slewing clutches on the first shaft are carried on ball bearings and are operated through ball-bearing thrust collars. The clutches drive a vertical shaft through bevel gears and this shaft, through compound reduction gearing in an oil-filled well formed in the revolving frame, drives the final slewing pinion geared with the slewing ring. A toggle-operated friction brake fitted on the slewing shaft is designed to hold the superstructure in any position relative to the undercarriage under all conditions of loading. The driving gear is of robust design to suit the severe conditions of reversing loads to which the unit is subjected. The slewing speed of the crane is 3 r.p.m.

Derricking

The clutch shaft of the derricking unit is connected to an extension of the slewing clutch shaft by a flexible coupling. Through a reversing bevel gear unit the derricking clutches drive a vertical worm shaft meshing with a bronze worm wheel which, in turn, drives the derricking barrel through spur gearing. The spur gears only serve to give correct positioning of the derricking barrel. On the lower end of the wormshaft is a friction brake which is fitted to ensure that the weight of the jib and load cannot reverse the worm unit unless it is positively driven by the clutches. This derricking unit is designed to carry sufficient rope and to have ample power to derrick all jibs up to 75ft long from the horizontal to their minimum radii, and also to satisfy the conditions of derricking with 25 per cent overloads at the rated radii and beyond.

Two powerful twin-plate clutches in the centre of the main transmission shaft drive the vertical shaft of the three-speed travelling gearbox through bevel gearing. A sliding pinion on the vertical shaft is used to select which of the three travelling speeds is required, a straightforward three-position quadrant without a gate being fitted in the control cabin. The final gear in the gearbox is splined to the vertical centreshaft which transmits the drive to the undercarriage. This gearbox is formed within the revolving frame and is filled with oil, small oil pumps being provided to maintain a flow of lubricant over the uppermost gears. It will be appreciated that the reversing clutches and the gearbox gives the three travelling speeds of 1, 3 and 5¼ m.p.h. in each direction of travel.

Heavy lugs are provided at the front of the revolving superstructure for the jib footpins, and one of two "A" frames can be fitted. The standard frame is suitable for the swan-neck jib and the 45ft lattice jib, and a high frame is used with the 60ft and 75ft lattice jibs. Both of these "A" frames are pin-jointed to the revolving frame to ensure that all members are in pure tension or compression and so prevent the development of secondary bending stresses. The pulleys fitted at the heads of the frames are mounted on phosphor-bronze bushes.

The slewing, derricking and travelling brakes and the main engine clutch of the crane are all mechanically operated through links, whilst all the other clutches and the release control for the main hoist brake are hydraulically operated. This hydraulic operation, it is pointed out, is not intended to help the driver, but is used as it provides a clean, neat and trouble-free method of transmitting the motion, and with it there is no question of increased movement or sponginess in operation due to wear. The firm's own design of servo gear is fitted to the power-operated steering gear of the crane, and it provides ample power for accurate steering of the heavy machine with the least manual effort on the part of the driver.

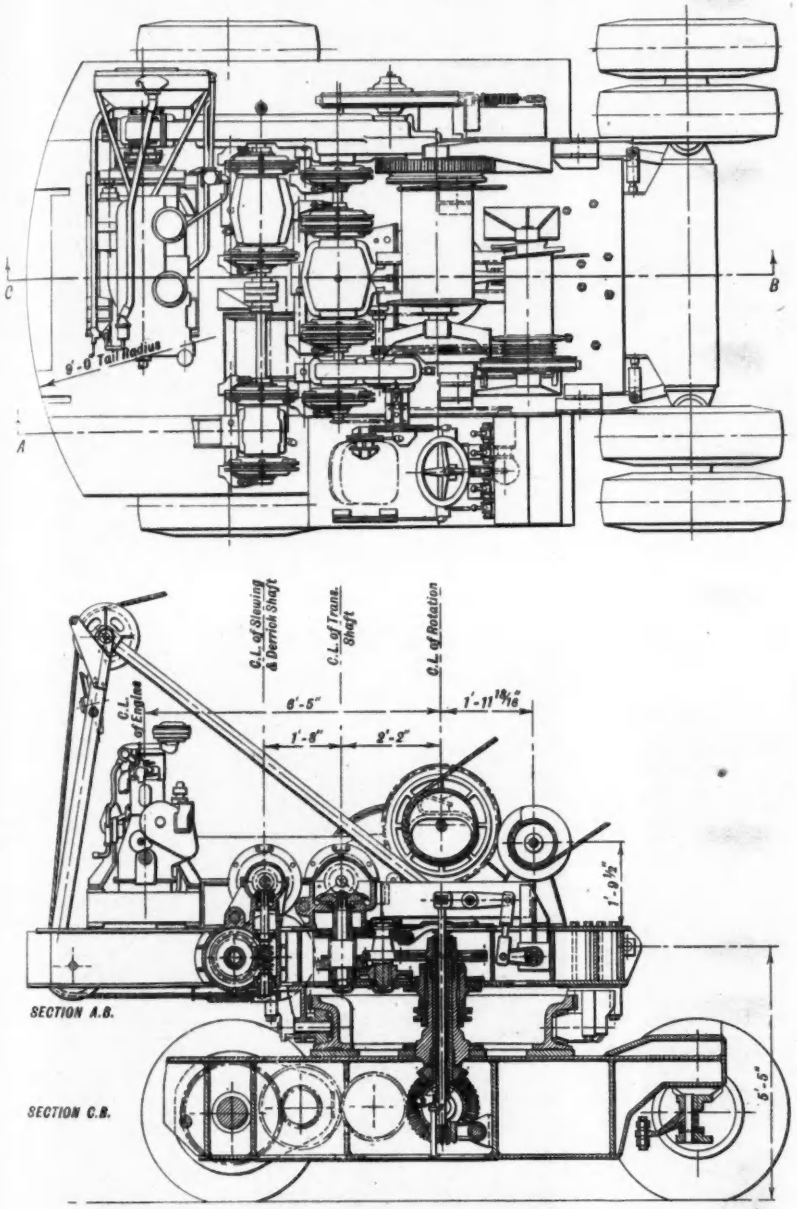
As already mentioned, various types and lengths of jibs can be fitted to the crane, and the standard jib head consists of an aluminium alloy casting having four positions for the jib rope pulleys. These four positions are provided for the following uses:—With one pulley in use, single-line lifting; with two pulleys in use in the outer positions, double-line lifting; with one "wide-mouthed" pulley in use, single chain-ring discharge grabs; with two rope pulleys in the centre positions, double-rope grabs; with a "wide-mouthed" pulley and a rope pulley in the centre positions, a double-rope grab having internal chain operation.

In each of the two left-hand positions of the pulley casting provision is made for the fitting of an eccentric roller bearing hub which actuates an overload indicator, when required.

The derricking rope pulleys are carried on the outside of the jib head casting and all pulleys are suitably guarded to prevent ropes jumping off. At the bottom end of the top section of the lattice jib assembly is fitted a shaft carrying two aluminium idler pulleys which are used to guide the hoist ropes and prevent them chafing on the jib. The lattice jibs are all of fabricated tubular construction.

A comprehensive lubrication system on the crane has been arranged to cover all essential points with the maximum degree of ease to facilitate maintenance work. All the gearing is enclosed and runs in oil baths apart from the final slewing ring, which, of necessity, has to be exposed, and the main hoist barrel gear ring. All of the stationary greasing points are coupled to conveniently situated grouped nipples. Continuous lubrication of the slewing rollers, final slewing pinion bearings, main hoist shaft bearing and auxiliary hoist shaft bearings is provided by a mechanical force-feed lubricator. This unit is driven from the hoist brake shaft through a free-wheel so that every time a load is lifted a metered quantity of grease is forced into all of the bearings served. Each lubricating pipe-line is separately fed through its own metering valve, which passes the appropriate quantity of lubricant to the bearing.

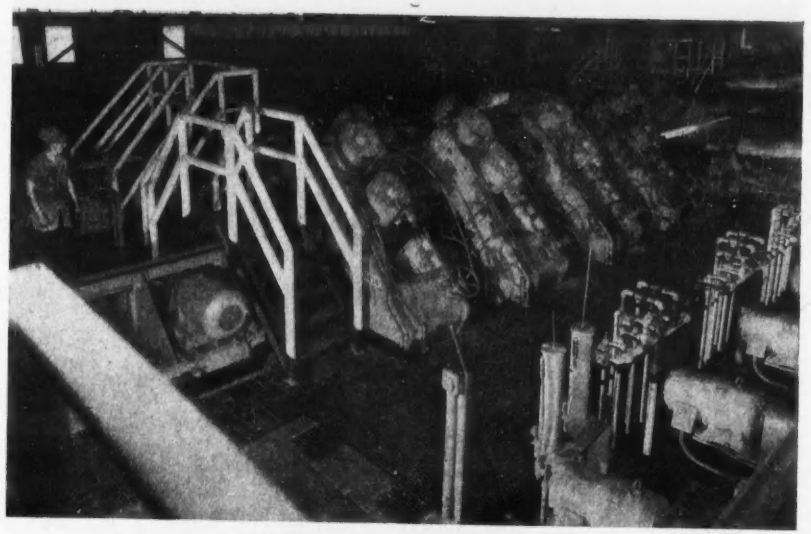
Large well-placed windows in the steel cab provided for the driver give a wide range of vision round the crane, and an unobstructed view of the load during operations.



GENERAL ARRANGEMENT OF CRANE

SEAMLESS TUBE MILL OF THE NATIONAL TUBE COMPANY, UNITED STATES

MANNESMANN PIERCING MILL



CONTINUOUS MANDREL MILL

STRETCH-REDUCING MILL AND REHEATING FURNACE

ROTATING SCREW ROLLER COOLING TABLE

American Seamless Tube Mill

WITHIN a general modernisation programme carried out at the Gary Works of the National Tube Company, a subsidiary of the United States Steel Corporation, an interesting and unusual seamless tube mill has been installed recently. This mill, which is an entirely new development, employs continuous rolling on a mandrel and incorporates the stretch-reducing process in twelve separately powered stands. Stretch-reduction is accomplished by speeding up each successive roll stand, the added speed from one stand to the next stretching the tube between them. The tension acts along the length of the tube and reduces its wall thickness, a method especially suited to the manufacture of small diameter tubing in long lengths. Delivery speeds of the mill range from 850ft to 1700ft per minute.

ROTARY HEARTH BILLET HEATING FURNACE

The new No. 3 seamless mill, basically, is an automatic continuous seamless and Assel combination mill, producing hot-rolled lengths of 45ft in light-wall tubing and 25ft in heavy-wall tubing, with sizes ranging from 1in to 3½in outside diameter. There are two separate continuous lines of inline heating chambers. The installation of these chambers in a continuous line for heating round billets is claimed to be the first one of its kind. Each installation consists of twenty-seven chambers, nineteen chambers being used to bring the cold billets up to the desired temperature and eight to hold or soak them to ensure even heating. The twenty-seven chambers in each line are grouped into six separately controlled zones, either gas or oil-fired. Tube billets are charged cold at predetermined lengths and are cut to the required piercing mill sizes by hot saws at the end of each furnace line. The tube billets then enter the piercing mill, which is of the conventional Mannesmann type, with inlet and outlet troughs. In the illustration opposite a pierced round is shown leaving this mill.

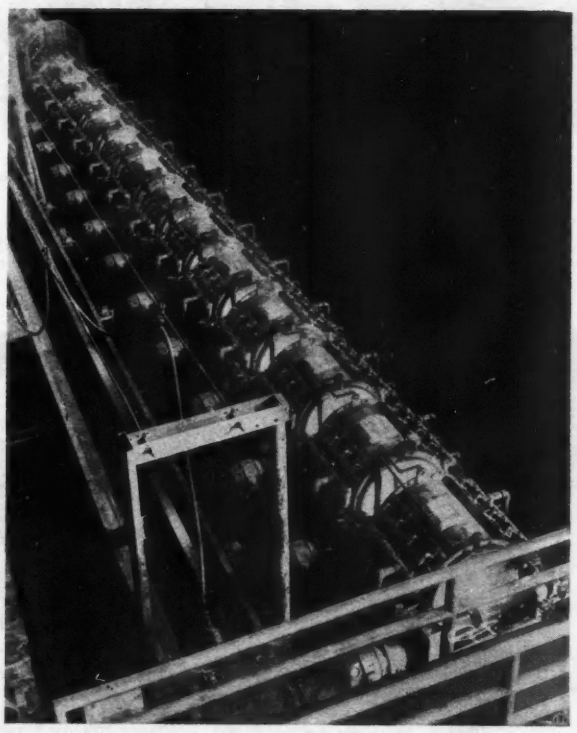
From this point onward, the path of the pierced shell is determined by the type of product to be rolled. When rolling small-diameter light-wall tubing a mandrel bar is inserted and both mandrel and tube pass through the eight-stand continuous rolling mill also shown opposite. The bar is then removed and returned for the next tube while the rolled tube passes through the reheating furnace and through the twelve-stand reducing stretch mill. The reheating furnace is of the roll-down type and has inlet and outlet water-cooled rollers. The furnace is 48ft long inside, has three-zone control and is equipped with furnace pressure, temperature and fuel controls. Like the mandrel mill, the stretch-reducing mill, which is illustrated opposite, is arranged with its successive stands inclined at right-angles to each other, each pair of rolls being inclined 45 degrees to the floor level. The rolls of each stand have semi-circular grooves, which alternately engage one side and the other of the shell circumference. By producing a speed differential between the successive roll stands tension is produced in the portion of the tube between the stands. This tension stretches the tube and creates a thinner wall and greater length. In this manner the stands are rolling the tube continuously thinner while also reducing its diameter. After leaving the stretch mill the finished tube passes across a cooling table to a multiple cold saw, where it is cut into lengths as required. Finally, it moves to the scales for weighing.

When rolling heavy-wall tubing, after leaving the piercing mill the pierced shell bypasses the eight-stand mandrel mill and passes directly through the reheating furnace to the twelve-stand sizing sinking mill. This mill is of conventional design, with a common motor operating the gear-reduction drives and the line shaft. Again the tube passes to the cooling table and through the multiple saw to the scales for weighing.

When rolling large-diameter, light-wall tubing the shell is passed from the piercing mill through the eight-stand continuous rolling mill but the Assel mill is by-passed. The tube is then reheated and passes through the twelve-stand sizing sinking mill and through a rotary sizer. The latter, too, is in accordance with conventional design, having the rolls set at an inclined axis. From this mill the sized tube moves to the cooling table, through the multiple cold saw and on to the scales. The cooling table is 160ft long and of the rotating, screw-roller type. As the tubes are carried across the table, they oscillate back and forth across the rollers approximately 6ft.

The most important item of existing equipment to be reconstructed under the modernisation scheme at the Gary Works was the No. 2 seamless mill. Originally built in 1930 to manufacture pipe and casing in lengths up to 48ft, the mill was shortened to 35ft during the last war to permit installation of additional machinery and reheating furnaces for alloy steel products. Under the post-war programme the mill was again changed to manufacture alloy steel stock up to 48ft long in sizes ranging from 3½in to 9in outside diameter. This alteration necessitated the removal of reheating furnaces and the relocation and redesign of other pieces of equipment. Among the major items of new equipment are a 60ft doughnut-type rotary hearth billet-heating furnace, having a capacity of 50 tons per hour, an automatic outlet-guide section trough for the No. 1 piercing mill, a reheating furnace ahead of the plug mill and a thirteen-chamber inline reheating furnace ahead of the continuous sizing mill. The rotary furnace, which is illustrated herewith, was designed to incorporate five individually walled zones, each with its own separate furnace controls and equipped to burn oil or gas, or oil and gas in combination. The charging machine at the left automatically feeds cold rounds as required on to the conveyor. The conveyor, in turn, is automatically actuated from the discharge end of the furnace by the manually operated discharging machine, which is in the foreground of the illustration.

Ahead of the continuous sizing mill there is a thirteen-chamber inline reheating furnace with completely automatic controls. These chambers are in a continuous line and grouped to provide



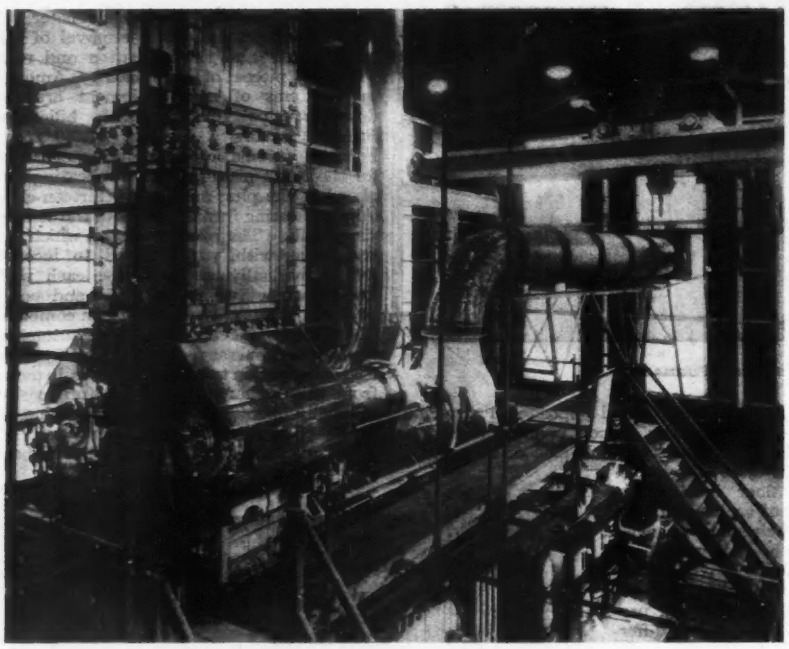
MULTI-CHAMBER REHEATING FURNACE

six separate heating zones, each individually controlled by an electric eye. A general view of the furnace is shown in the photograph reproduced on p. 249.

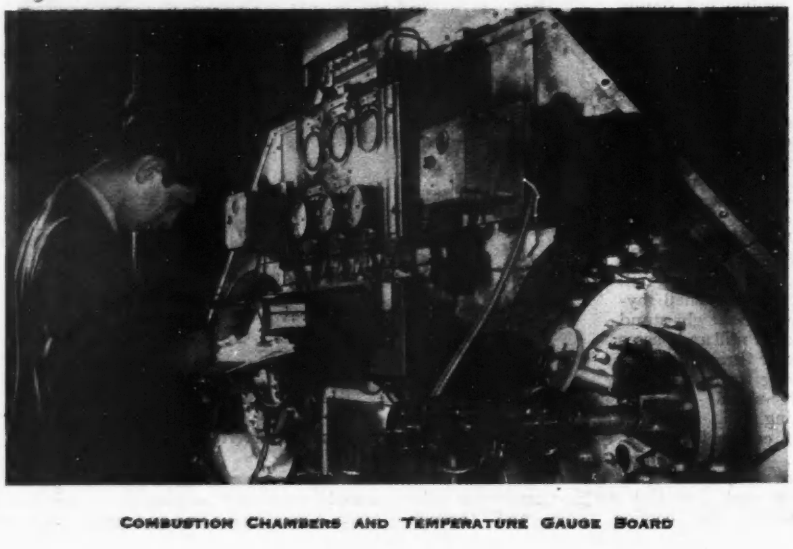
Two finishing floors handle the full range of products manufactured by the two seamless mills. No. 1 floor is situated near the No. 3 seamless mill and deals with both hot-rolled and cold-drawing tubing from $\frac{1}{16}$in to 3$\frac{1}{2}$in outside diameter. No. 2 floor is situated near the No. 2 seamless mill and can handle tubing of 3$\frac{1}{2}$in to 9in outside diameter. Both floors are equipped with straightening machines, cut-off machines, hydrostatic testing machines, pipe-coating equipment and tables for inspection and packaging. Tubing other than hot-rolled requiring further treatment, such as pickling, reducing, cold-drawing, pointing, normalising and intermediate and final annealing, is handled in the processing department. The furnaces are continuous roller-hearth equipments for normalising and bright annealing and convection equipments for heat treatment in order to improve the tensile properties of the material. The cold-working division consists of drawbenches of 20,000 lb to 300,000 lb capacities and tube reducers to handle tubing of 1$\frac{1}{2}$in to 3$\frac{1}{2}$in outside diameter.

Marine Gas Turbo-Alternators

MANY problems in the construction of gas turbines as prime movers for ship propulsion still exist which are difficult of solution, and no doubt will require much time and experiment before the answers are found. However, the attack on the problem will be advanced a stage further when the gas turbine alternator set, which the British Thomson-Houston Company, Ltd., has constructed for the Anglo-Saxon Petroleum Company, Ltd., is installed for sea trials in one of the company's tankers. As mentioned in our issue of January 12th, the M.V. "Auris," a tanker of 12,000 tons deadweight, was built about three years ago and when the machinery arrangements were planned special provision was made for the fitting and testing, at some future date, of a gas turbine. The existing machinery is also of an experimental nature and consists of four Hawthorn-Sulzer eight-cylinder, single-acting, four-stroke, airless injection supercharged oil engines, each of 1105 b.h.p. They are direct coupled to B.T.H. double-unit, 830kW, three-phase, 50 c/s, 1600V alternators, which supply power to a B.T.H. single-unit a.c. propulsion motor of 3750 s.h.p. at 120 r.p.m.



GENERAL VIEW OF MARINE GAS TURBO-ALTERNATOR



COMBUSTION CHAMBERS AND TEMPERATURE GAUGE BOARD

One of the diesel engines will be replaced by the gas turbine electric set illustrated on this page, and it weighs nearly 50 tons. Having completed its shop trials, it is now ready for dismantling and re-erection on board ship. At the invitation of the British Thomson-Houston Company, Ltd., we were able to inspect the plant while still in operation on the test bed and to note general running conditions.

GENERAL DESCRIPTION

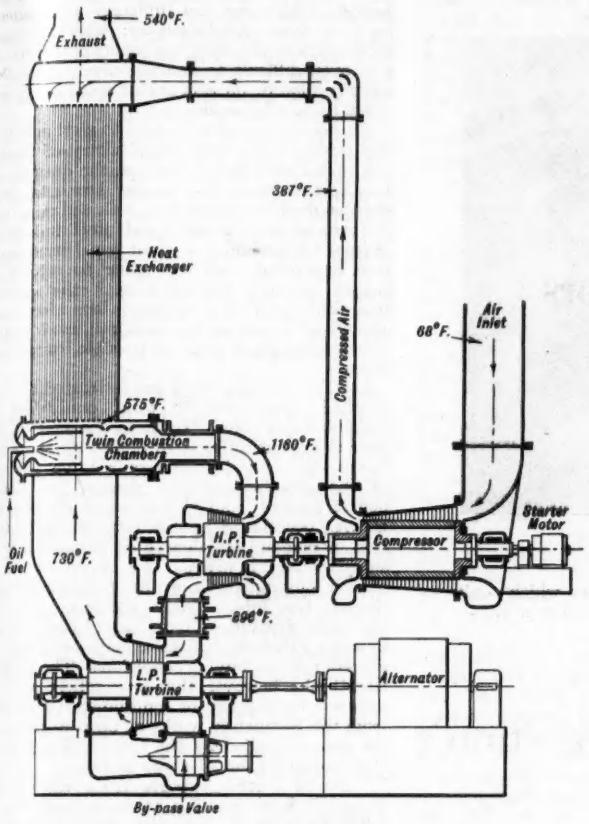
We reproduce on page 251 a diagrammatic arrangement of the set in which the various component parts are shown approximately in accordance with the actual construction. The machine operates on the open-cycle system, in which the air is drawn in through an inlet duct to the compressor and, after compression, passes to the heat exchanger inlet drum and then through the tubes to the two outlet drums, which incorporate the combustion chambers. Short pipes lead the hot combustion gases to the h.p. turbine, thence to the l.p. turbine, after which they pass to the heat exchanger and travel upwards externally along the length of the pipes, in contra-flow to the compressed air inside them. The gases are then discharged to the atmosphere.

The unit consists of a main base, upon which the l.p. turbine and alternator are mounted and within which are a lubricating oil tank and alternator air cooler. The supporting steel frame has sufficient rigidity to permit the set to be handled as a unit and only requires a simple seat to be built in the ship. The h.p. turbine and compressor, together with the starting motor, are carried on a fabricated steel frame, which is bolted to the main base, and this arrangement brings the h.p. turbine above the l.p. turbine and the compressor above the alternator. Supported from the main base and mounted on the l.p. turbine exhaust are the twin air outlet drums, in which the combustion chambers with their single oil burners are fitted as can be seen in one of our illustrations. Oil is supplied to the burners at a pressure of 250 lb per square inch and a temperature of 240 deg. Fah. The drums are surmounted by the heat exchanger, which operates on the contra-flow principle; the stack is built up of widely pitched mild steel tubes of 1$\frac{1}{16}$in outside diameter and standard gauge, and has a single inlet drum.

Below the l.p. turbine is a by-pass valve, which is arranged to by-pass gases from the h.p. turbine direct to the heat exchanger so that no power is generated by the l.p. turbine. For starting, the by-pass valve is opened and the 50 h.p. starting motor, which is connected to the h.p. turbine and compressor shaft, is run up to the ignition speed of 1200 r.p.m. At this point the oil burners are opened and the set is gradually accelerated by the gas turbine with diminishing assistance from the starting motor. When the shaft speed reaches 1800 r.p.m. it is a characteristic of the motor that its torque falls to zero, whereupon it is automatically disconnected.

The l.p. turbine, which is shown in our photograph, has six stages of impulse reaction blading, designed on the vortex principle, of Hecla A.T.V. steel and both the rotor and casing are of ferritic steel, as used normally for steam turbines. Blading for the h.p. turbine is similar to that of the l.p. turbine, but there are seven stages and the material is a stainless austenitic steel, Rex. 337A. The rotor and casing are of austenitic steel, the former being Rex. 326F material and having welded shaft ends. Nimonic steel has been used for the combustion chamber shells. The blading of the twenty-four-stage com-

pressor is of austenitic stainless steel for running in a sea atmosphere, while the rotor is of normal ferritic steel and the casing of stainless iron.



DIAGRAMMATIC LAY-OUT OF GAS TURBINE SET

For insulation of the unit magnesia has been used and covered by aluminium sheets.

Design Particulars

The set was designed for an ambient air temperature of 68 deg. Fah., a turbine inlet temperature of 1160 deg. Fah., with a maximum operating temperature of 1200 deg. Fah. Speeds of the compressor and h.p. turbine shaft and of the l.p. turbine and alternator shaft were to be 5750 and 3000 r.p.m. respectively. At the design conditions the output of the l.p. turbine was expected to be 1200 b.h.p. or 860kW on a fuel consumption of 0·7 lb per b.h.p. per hour, to give a thermal efficiency of 20 per cent. To ensure an adequate service life a moderate initial gas temperature was adopted and inter-cooling during compression was omitted due to the small mass flow of air. Design conditions and the small size of the unit decided the thermal efficiency, but as the main object of the experiment was to test the reliability of the gas turbine at sea, fuel consumption was considered of secondary importance.

It is acknowledged that the general lay-out is not ideal, but it has been governed by the space available on the ship and this particularly applies to the arrangement of the turbines, which precludes undertaking any major overhaul at sea. The sea trials are intended to check the reliability and performance of the plant when on continuous full-load duty and the set will not be running when the ship is manœuvring. As mentioned earlier, there are many problems still extant and the question of absorption of power during manœuvring still awaits final solution. The by-pass valve, which the B.T.H. Company has designed and which is fitted below the l.p. turbine, is intended to assist in the solution of the problem. It has two functions one of which is to act as a safety device. Should the revolutions of either turbine shaft reach the trip speed, the valve opens and the gases from the h.p. turbine bypass the l.p. turbine and pass directly to the heat exchanger. At the same time the fuel supply is shut off so preventing overspeeding of the alternator in the event of a sudden failure of the electrical load. The second function of the valve is to assist starting, for when it is open the pressure behind the h.p. turbine is greatly reduced and the turbine can then help in driving the compressor at starting speeds, thus reducing both the power and the time required for starting.

Shop Trials

Preliminary trials commenced in June, 1950, and during the next six months the gas turbine was run on gas oil, at varying loads from less than quarter-load to the higher values. The runs served to establish the soundness of the mechanical construction, to adjust clearances, to investigate distortion, to analyse the causes of noise and to make adjustments necessary to obtain good combustion at varying loads. During the initial running period there was some slight distortion of the h.p. casing, but this remained static and clearances were not affected. The smoky exhaust proved that there is an appreciable difference between the operation of a combustion chamber under pressure and at atmospheric pressure and a check showed that although there was a fine deposit of soot on the heat exchanger tubes there was none on the turbine blading. Under conditions of good combustion the recorders indicated the presence of fifty parts of carbon monoxide in one million.

During the first five weeks of this year the plant underwent performance and endurance trials and was operated for 528 hours, which included 335 hours on heavy oil having a viscosity of 1500 seconds Redwood No. 1 at 100 deg. Fah. and which was not centrifuged. The successful running on heavy oil is encouraging as the results of early tests on an open cycle turbine, given in a technical paper, indicated that any fuel other than distillates would cause difficulties. The no-load consumption with the l.p. turbine idling at 1500 r.p.m. is about 100 lb per hour and 200 lb per hour at 3000 r.p.m.

When starting, the peak turbine-inlet temperature reached was between 900 deg. to 1000 deg. Fah., but as the idling speed, which is approximately 3000 r.p.m. for the h.p. turbine, was approached the temperature fell gradually to between 650 deg. to 750 deg. Fah., according to the ambient conditions and the l.p. turbine speed. There is no air filter at the compressor intake duct and it was noted, with particular interest, that there was no falling-off in compressor efficiency, but sea voyages will show if salt-laden air will have any effect upon compressor performance.

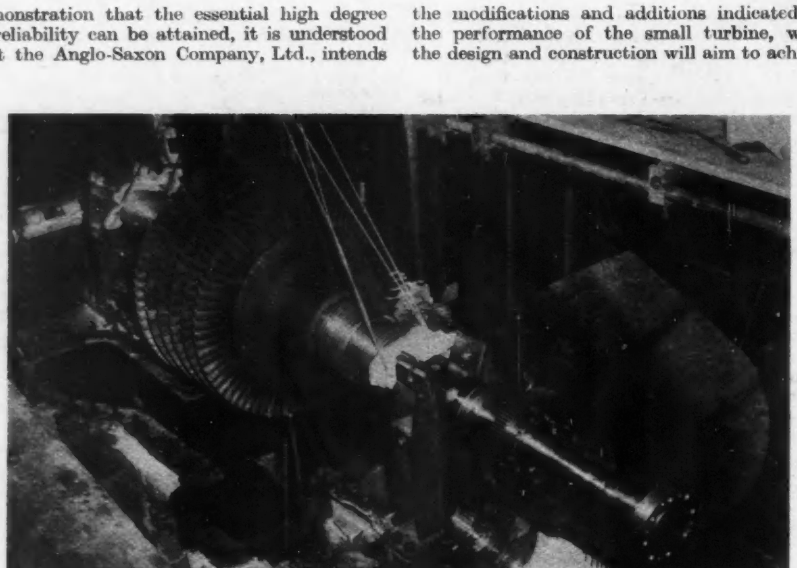
In the accompanying table are given the results of two trials, one run at full load on gas oil and the other at maximum load, using heavy oil. The figures recorded in the first trial have been corrected to design conditions and are given in the second column.

When considering the performance results given in the table it should be remembered that the set was tested as designed, no modifications having been made. It is evident that neither the compressor nor the h.p. turbine are running at maximum efficiency and that the turbine inlet temperature is lower than the maximum permissible. Another point to note is that a low heat recovery heat exchanger, having a thermal ratio of about 50 per cent, is installed. Upon the completion of sea trials of the present unit and the satisfactory

Gas Turbine Test Results

Item	January 4, 1951: Full Load: Gas-Oil		January 25, 1951: Maximum Load: Heavy Oil
	Test Readings	Corrected to Design Conditions	Test Readings
Compressor inlet:			
Temperature, deg. Fah.	43	68	39
Pressure, lb per square inch, absolute	14·13	14·64	14·17
Compressor outlet:			
Temperature, deg. Fah.	320	360	332
Pressure, lb per square inch, absolute	56·17	58·24	60·03
Combustion chamber inlet:			
Temperature, deg. Fah.	485	532	500
Pressure, lb per square inch, absolute	55·61	57·61	59·41
H.P. turbine inlet:			
Temperature, deg. Fah., approximate reading	1037	1113	1085
Pressure, lb per square inch, absolute	54·10	56·09	57·83
L.P. turbine inlet:			
Temperature, deg. Fah.	774	837	820
Pressure, lb per square inch, absolute	22·58	23·41	23·50
Isentropic efficiency, per cent:			
Compressor	87·0	—	86·3
H.P. turbine	85·2	—	84·3
L.P. turbine	88·4	—	89·5
Heat exchanger:			
Gas inlet temperature, deg. Fah.	651	707	682
Gas outlet temperature, deg. Fah.	482	529	496
Pressure drop, lb per square inch	0·21	0·23	0·26
H.P. turbine speed, r.p.m.	5850	5996	6000
L.P. turbine speed, r.p.m.	2800	2870	2940
Compression ratio	3·98	3·98	4·24
Air mass flow, lb per second	27·6	27·9	28·8
Fuel consumption, lb per hour	773	821·5	925
Output at alternator terminals (corrected kW)	875	930	1022
Fuel rate, lb per kWh	0·884	0·884	0·905
Overall thermal efficiency, per cent	21·1	21·1	21·4

demonstration that the essential high degree of reliability can be attained, it is understood that the Anglo-Saxon Company, Ltd., intends to build an engine of larger power. The new unit will be of 6500 h.p. and will incorporate the modifications and additions indicated by the performance of the small turbine, while the design and construction will aim to achieve maximum efficiency, a factor which could not be attained by a unit of small power.



ROTOR OF LOW PRESSURE TURBINE

The British Iron and Steel Federation's Annual Report

LAST week, the British Iron and Steel Federation published its annual report. It is a useful document, as it places on record the principal activities of the privately owned iron and steel industry during 1950 and shows how those activities were successfully co-ordinated by the work of the Federation.

The first section of the report deals with the events of 1950, consequent upon the passing of the Iron and Steel Act, 1949. After the announcement by the Minister of Supply, in October last, that the vesting date for the industry would be February 15th, 1951, and the setting up of the Iron and Steel Corporation, the Council of the Federation immediately considered the policy to be adopted during the months ahead. It unanimously agreed that, since the Act imposed certain duties on the new Corporation, facilities for carrying out those duties should be provided by the industry as necessary. At the same time, it was essential for those in the industry, not only to continue faithfully and loyally to manage their particular firms, but also to preserve, as far as possible, the arrangements which had been so successful up to the present. In discussions which began last November, the chairman of the newly appointed Corporation asked the Federation for assistance in finding four steelmakers who might join the Corporation by February 15th of this year. The Council of the Federation, while adhering to the view that it was not reasonable to expect any steelmaker to join the Corporation, offered to co-operate by placing at the Corporation's disposal, in a consultative capacity, the services of the president of the Federation and three leading steelmakers. That, it was urged, would enable a review to be made of all problems which might be expected to emerge in the event of the Corporation becoming sole shareholder of certain steel companies. In conveying that offer, the president of the Federation emphasised that the industry was most anxious that there should be no failure on its part to strive to serve the national needs in the future as faithfully and successfully as it had done in the past. It was added that the need for continuity in the industry's endeavour to render maximum service to the country was underlined by the existing international situation.

Steel Supplies

The report then surveys the subject of steel supplies during 1950, explaining that outstanding home orders, which had decreased by about 25 per cent in 1949, amounted at the beginning of January, 1950, to nearly four months' work. During the early part of last year a further slight fall became apparent, but it was largely offset by increased export orders. By the end of March shortages in the home market were confined almost entirely to sheets, and it was on that account that home distribution control was abandoned after full discussion by inter-departmental committees.

In the weeks immediately following the relaxation of steel control on May 22nd, the number of home orders did not rise significantly. But the situation was radically altered by the outbreak of the Korean war, and demand increased sharply from about the end of June. By the end of November outstanding orders amounted to 6,908,000 tons. Much of the increase, the report says, was undoubtedly due to panic buying as a result of the international situation and to anticipation of the effects of the Government's rearmament programme. In order to increase supplies to the home market the industry decided to restrict the level of exports in the period December 1, 1950, to March 1, 1951, to that which had obtained in the third and fourth quarters of 1949. That measure was calculated to make a further 125,000 tons of steel available to the home market.

The biggest individual problem throughout last year was that of sheets and tinplate, the home supply of which is not likely to be eased until the latter half of this year, when output should increase as a result of the coming into operation of the new steel works and continuous mill at Margam. Every effort has been made to increase supplies by imports, but these—particularly from the U.S.A.—have not materialised to the extent hoped for. Among other products in short supply during the later months of last year were billets and wire rods, which caused some hardship among re-rollers and wire manufacturers. This was a shortage brought about by the difficulty of obtaining supplies from the Continent, where demand increased sharply, and, the report comments, it was even difficult to secure delivery of orders already placed, on account of more attractive offers from other sources.

On general matters relating to steel supplies, the report states that the Ministry of Supply has raised with the Federation the question of how best to ensure that the requirements of the defence programme are met with the minimum disturbance of the iron and steel industry's normal production. A small panel was therefore appointed last September to advise on supply matters connected with the defence programme. Technical panels are also being appointed to advise on classes of steel with a view to keeping as much as possible to standard steels.

Steel imports last year are estimated to have totalled about 455,000 tons, equivalent to 545,000 ingot tons. Towards the end of the year it proved difficult to obtain all the additional Continental steel required, on account of the greatly increased demand on Continental makers from all sources, including the U.S.A., occasioned by the international situation, a demand which was accompanied by a sharp increase in prices. It is hoped that those chaotic buying conditions are only temporary, though the international situation and the uncertain demands of rearmament programmes in many European countries may well intensify current nervous buying conditions. The Federation thinks, however, that some relief should be afforded by supplies of semi-finished steel due from the Normandy works at Caen in payment for plant supplied by the United Kingdom in the reconstruction of those works.

"Direct" steel exports from the United Kingdom were running at an annual rate of 1,930,000 tons in the third quarter of 1950, compared with an annual rate of 1,650,000 tons at the end of 1949. In addition, "indirect" exports, that is, of goods made from steel, increased during the first nine months of 1950 by 15 per cent, compared with the corresponding period of 1949. The report notes that in February and March of last year Continental steelmakers became very short of orders and prices quoted dropped to a low level. In accordance with the policy of maintaining stable prices, however, United Kingdom export prices were kept at their existing level, although some concessions were made on large quantities of re-rolled products. After the start of the Korean war and the beginning of rearmament programmes by the major steel-making countries, steel demands built up rapidly. Continental makers booked large orders, particularly from American merchant firms, and prices again hardened. With the increased demand on Continental makers inquiries for exports from the United Kingdom increased considerably. However desirable it may seem to curtail exports, the report says, it has been emphasised as essential, in the interest of the national economy, for exports to be maintained as far as possible to certain countries, particularly to the Commonwealth, dollar and dollar-saving areas, and markets from which we import raw materials.

Raw Materials

An important section of the Federation's report is that dealing with raw materials. A survey by the Raw Materials Co-ordinating Committee of the requirements for an ingot steel production of 16,000,000 tons in 1950 concluded that adequate supplies of raw materials would be available. A high level of receipts of both home and imported scrap was necessary and the maximum possible production of pig iron was considered essential as a safeguard against reduced scrap imports. As was expected, scrap imports became drastically curtailed during the last four months of 1950, but high steel production was maintained by the substitution of a proportion of pig iron for scrap, and by some reduction of scrap stocks

from the high level which they had reached in the middle of the year.

Arrivals of imported ore last year totalled 8,726,000 tons, compared with 9,045,000 tons in 1949. Last year's consumption was 9,066,000 tons, compared with 8,794,000 tons in 1949. Stocks of ore at the end of last year were 945,000 tons, which indicated a reduction of 337,000 tons since the beginning of the year. This fall occurred mainly in the latter part of 1950, following shipping difficulties resulting from the Korean war and also the programme for coal imports from America. The increased f.o.b. ore prices which followed devaluation in the autumn of 1949 were offset by a reduction in freight rates. Since the start of the war in Korea, however, there have been further f.o.b. price increases, and a swift advance in freight rates—especially since the arrangement for importing coal—is now increasing substantially the cost of imported ore. After discussing prospective ore supplies from Wabana, Conakry and Sierra Leone, the report observes that American purchases from the European zone in 1951 are expected to be confined to approximately the same amount as in 1950. America is, however, likely to be seeking ore supplies from normal European sources for the next few years, until the first supplies resulting from new developments in Venezuela and Labrador become available. At present, America is receiving about 3,000,000 tons of iron ore a year from the European zone, compared with about 1,000,000 tons in 1946–47 and about 500,000 tons pre-war. No difficulties were experienced during last year over the supply of home ironstone. Consumption totalled 12,775,000 tons, compared with 13,026,000 tons in 1949.

Arrivals of imported scrap during the fourth quarter of 1950 averaged 20,700 tons a week, compared with a weekly average of 42,400 tons for the first nine months of the year. The greatly reduced rate of importing was the result of the reduction in supplies of German scrap, which, for the first eight months of last year, were at an annual rate of approximately 2,000,000 tons. Tentative arrangements are being discussed with German scrap merchants, with the approval of the German authorities, for the import of 1,000,000 tons this year. It is envisaged that this should be at a rate of 75,000 tons a month for the first half of the year and 105,000 tons a month thereafter. Receipts of home-bought scrap during last year averaged 79,700 tons a week, compared with 84,100 tons a week in 1949. In view of the reduced import programme over the last four months of last year, supplies of imported scrap to consumers had to be cut by half, and in distributing the available supplies every care had to be taken to minimise the interference with steel production. Some consumers, the Federation states, were able to substitute a proportion of pig iron, thus making it possible to reduce the ratio of scrap consumption to steel production from the peak level of 63–64 per cent obtaining in the summer months to about 61 per cent at the end of the year. Although pig iron and scrap stocks have fallen since the beginning of 1950, they are still above the 1947–48 level.

As to fuel, the report points out that, owing to the operation of additional furnace plant, consumption of coke by the steel industry increased during the latter part of last year and is expected to rise further in the first quarter of this year. Consequently, considerable concern is felt at the situation, and the National Coal Board has been strongly urged to ensure the fulfilment of the steel industry's programmed requirements. The Federation has asked the Coal Board to reintroduce at a number of its plants the blending of Midland coking coals, which are not in themselves suitable for blast-furnace coke, with the higher quality Durham coking coals. So far, the steel industry has borne the additional cost involved. The quality of coke continues to be below the standard required by the steel industry, although recently a limited improvement has been noted. The continued fluctuation in quality is, however, a matter of concern, and a joint committee, set up by the Federation, is examining the question of a more general blending of coals with a view to quality improvement. At the same time, it is noteworthy that the total coal consumed per ton of finished steel is estimated to have been 34·4 cwt in 1950, compared with 62·7 cwt in 1923.

The iron and steel industry was associated with representations made last year by the Federation of British Industries to the oil companies about the advance in the price of oil fuel following devaluation. Consumption of fuel oil in open-hearth furnaces in 1950 was 603,000 tons, compared with 562,000 tons in 1949, and a negligible quantity before the war.

Iron and Steel Development Plans

The report summarises the progress made during 1950 with the plan for the development and modernisation of the British iron and steel industry, explaining that expenditure last year on the works involved amounted to about £44,000,000. The present development plan is due to be completed in 1953–54, and the Development Committee of the Federation therefore felt that a second plan should be prepared, based on the knowledge and experience gained in carrying out the first. An Advisory Committee on Development has been set up under the chairmanship of Mr. N. H. Rollason, with the following terms of reference: "To investigate and report on the progress achieved under the present development plan and, in relation to that progress, to formulate a second development plan in the light of the probable future demand for steel by product, the probable future availability of raw material supplies, and the desirability of reducing costs and improving quality." All member firms of the Federation have been asked to advise the Committee, as early as possible, of their general future intentions for modernisation and/or development, and in due course specific proposals will be required. Meanwhile, the Committee is studying the stage reached under the present plan and the capacity estimated to be available when it is complete. In this connection it has asked for an assessment of the capacity of existing rolling mills, based on the maximum and average output. Concurrently, a study is being made of the likely demand for the various steel products over the period 1955–60.

Miscellaneous

Other matters dealt with in the report are the Federation's interest in the discussions on the Schuman Plan, its participation in the work of the Anglo-American Council on Productivity, and work on the co-ordination of steel standards and steel design. There are also sections dealing with transport, labour relations, training, and the important work of the British Iron and Steel Research Association, which has now been going on for five years. Then, there is a reference to costs and prices in the iron and steel industry, it being noted that increased transport costs which became effective last year were estimated to involve an increase in steelmaking costs of approximately 10s. per ton of finished steel. The industry, however, in order to avoid any action which might further aggravate the spiral of inflationary price increases, and particularly any weakening of the competitive position of steel-using industries in world markets, decided not to pass on to consumers that increased cost, and to maintain—for the time being—the existing level of steel prices.

Current Production

As well as publishing its annual report, the British Iron and Steel Federation last week issued figures relating to the output of iron and steel in the month of January—the last complete month prior to "vesting day." Production of steel ingots and castings averaged 305,900 tons a week, which represented an annual rate of 15,907,000 tons, the highest rate of production ever achieved in January, which is, of course, affected by the New Year holidays. Pig iron output averaged 183,100 tons a week and was thus at an annual rate of 9,520,000 tons, compared with a rate of 9,742,000 tons in January, 1950.

Rudolf Julius Emanuel Clausius
1822—1888

(Contributed)

There has lately been commemorated the centenary of the publication—Berlin, 1850—of the treatise: "On the Motive Force of Heat, and the Laws Regarding Heat which Can be Deduced Therefrom." It was this treatise which revealed Rudolf Clausius as a mathematical physicist of outstanding eminence. We may note that in the previous year James Prescott Joule had published the results of a series of experiments carried out with a view to determining the mechanical equivalent of heat—experiments which confirmed the law of the conservation of energy and established the dynamical theory of heat. Joule was thirty-one years of age when, in 1849, he presented his results to the Royal Society. Clausius was in his twenty-eighth year when he published the paper mentioned above, and Carnot was also twenty-eight when the "Réflexions" appeared. We mention Carnot for the reason that Clausius, in his Berlin paper of 1850, applied himself to a further development of the deductions of the great Frenchman.

In the popular imagination, Clausius has come to be associated mainly with the enunciation of entropy, though it was not until 1865 when the philosopher was a professor at Zürich—that he first made use of the expression "entropy" (in the German form "entropie"), which he took from a Greek word signifying "transformation." While the relationship between energy and entropy was not formally enunciated by Clausius until 1865, adumbrations of this relationship are to be found in the paper published in 1850. Professor E. Schmidt, of the Technical High School, Brunswick, has, in a recent communication to the Z.V.D.I., reviewed the work of Clausius, calling attention not only to the paper published in 1850, but to the papers published in 1854 ("On Alternative Formulation of the Second Law of Thermodynamics") and 1865 ("On Alternative Formulations of the Laws of Thermodynamics which are Convenient in Application"). In these three papers Clausius made his momentous contributions to the science of thermodynamics, in which science he may be bracketed with Carnot. Indeed, it cannot be questioned that while the reasonings of the brilliant Frenchman stand out among the most conspicuous triumphs of the deductive method in science—just as the work of Joule has become a noble monument of the experimental method—it remained for Clausius, a mathematical physicist, to declare that:

(1) The energy of the world is constant.

(2) The entropy of the world tends to a maximum.

In saluting the memory of Rudolf Clausius on the centenary of the first of his epoch-making papers, it is appropriate to recall that he has been described not only as a world-renowned scientist and teacher, but as a most lovable man and a fatherly friend to his students. ("Ein liebevoller Mensch und ein väterlicher Freund seiner Schüler.")

Renold Chain Clutch Adjustment.—A new method of adjustment has been introduced in redesigned chain clutches now being made by the Renold and Coventry Chain Company, Ltd., of 28, Deansgate, Manchester. The design and principle of operation of these clutches is unchanged, but adjustment is now effected through two wedge-type expander bolts, which ride over serrated washers giving a "click" adjustment. The original design of clutch adjustments entailed the use of a gauge and a number of setting points. With the improved design all that is necessary is the tightening of two nuts, until all clearance is taken up, and the slackening back of the nuts a specified number of "clicks" to give the necessary running clearance.

Small Ball Races.—We have received from Miniature Bearings, Ltd., 192, Sloane Street, London, S.W.1, one of the latest ball races it now distributes in this country. This race, type "C 1·5," consists of a pressed steel cup, dust cover, ball cage and three chrome steel balls, and its overall dimensions are 1·5mm diameter by 0·93mm high. The race is designed for a 60 deg. pivot and is the second smallest size supplied by the firm, the smallest size bearing being 1·10mm by 0·70mm.

Metallurgical Topics

Ductility of Metals at Low Temperatures

A SHORT discussion of the sub-zero properties of metals, summarising some recent investigations, appeared in *Iron Age* last October.[1] When any metal or alloy is exposed to temperatures below zero, its modulus of elasticity, hardness, yield, fatigue and ultimate strength all increase as the temperature decreases. Ductility (as measured by reduction of area) and toughness (as measured by notched-bar impact value) may increase, decrease or undergo no change depending on the metal used and the temperatures involved. The outstanding example of a material which, over a narrow range of temperature, changes from being ductile and tough to a condition giving brittle fracture is mild steel. The form of the ductility/temperature curve depends on the condition of the material. At the U.S. National Bureau

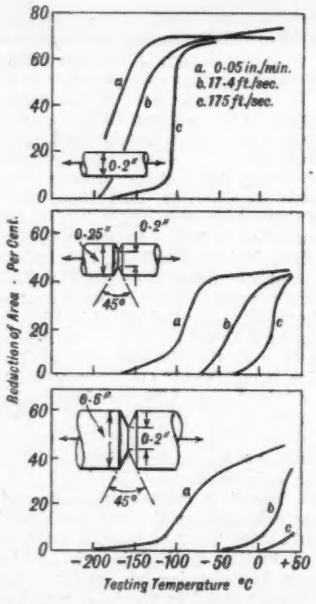


FIG. 1—*Effect of Testing Temperature on the Ductility of 0·17 per Cent Carbon Rimming Steel Under Various Testing Conditions (Jones and Worley. Quoted by Ripling*[1])

of Standards[2], for example, the tensile properties of ingot iron at low temperatures have been a subject of research and the true stress-strain curves of the material (carbon 0·02 per cent) in various conditions of mechanical and heat-treatment were determined. In the hot-rolled and normalised conditions the reduction of area showed a rapid fall between −160 deg. and −196 deg. Cent. In the quenched and tempered and the cold-drawn conditions, similar low values were attained at −196 deg. Cent., but the fall was more gradual, starting at about −80 deg. Cent. These temperature ranges refer to tests on plain unnotched tensile specimens. The actual transition temperature at which the change from tough to brittle fracture occurs depends greatly on testing conditions. Transition temperatures of different materials can be compared only when they are obtained under identical conditions of testing.

The observed ductility is affected by rate of strain and condition of multi-axial stress. The effect of speed of straining and of form of notch in tensile test pieces is shown in Fig. 1. Increase in the severity of the test, whether by increase in rate of straining or by notching or by deepening the notch, raises the transition temperature. Increase in test section size is generally thought to move the transition temperature to a higher value, but systematic investigation of this is difficult, as it is essential to eliminate the influence of heat-treatment size, which, in its effect on cooling rate and microstructure of the material tested, may introduce a complication. It is generally impossible to provide a quantitative relation between the various embrittling factors, each of which will cause a rise in the transition temperature. All that can be said is that the lower the transition temperature obtained in a

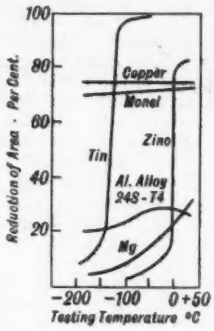


FIG. 2—*Low-Temperature Ductility of Some Non-Ferrous Metals and Alloys (Quoted by Ripling*[1])

standard test on a particular material the better it will be able to withstand a combination of embrittling factors.

It is not steel only which shows a transition temperature. Non-ferrous metals of the face-centred cubic group (e.g., copper, nickel, aluminium, &c.) do not lose their ductility at low temperatures, but other non-ferrous metals show a rapid fall in reduction of area similar to that shown by steels. This is shown in Fig. 2 for tin, zinc and magnesium; tungsten and molybdenum also show a transition temperature.

Effect of Prestraining

Various methods have been employed to throw light on the existence of the transition temperature. One method of study has been to strain a number of ordinary unnotched tensile specimens by various amounts at room temperature and then continue the straining to fracture at a lower temperature; in other words, to test at a low temperature test pieces which have been prestrained at room temperature.[3] The most interesting feature of such tests is revealed by plotting the ductility retained at low temperature against the prestrain. The ductility is conveniently expressed as the "maximum natural strain," equal to $\log_e(A_o/A)$, where A_o is the original area and A the final area of cross section.

There are two essentially different types of behaviour. One is represented by Fig. 3, in

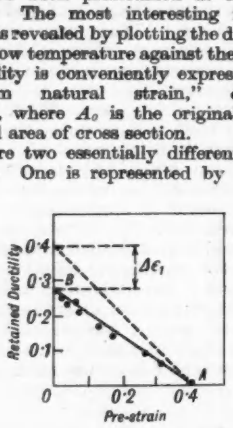


FIG. 3—*Ductility of Aluminium Alloy 24 S–T 4 Prestrained at Room Temperature and Tested at −196 deg. Cent. (Quoted by Ripling*[1])

which the low-temperature ductility of the aluminium alloy 24 S–T 4 (copper, 4·5, manganese 0·6, magnesium 1·5 per cent), which showed no transition temperature (Fig. 2), is reduced in proportion to the prestrain undergone. There is a straight line from the point *A* representing ductility at room temperature to the point *B* representing the ductility at −196 deg. Cent. of the alloy without prestrain. In the other type (Fig. 4) the curve joining the same two terminal points is irregular. With increasing prestrain the ductility at low temperatures passes through a minimum, then increases to a maximum and finally falls off to zero as the prestrain approaches the fracture ductility at room temperature. This type of curve is characteristic of a large number of annealed steels which have been stretched at room temperature and then tested at low temperatures.[4] The upper curve shown in Fig. 4 is that of a steel containing carbon 0·42 and manganese 1·81 per cent, oil hardened from 830 deg. Cent. and tempered at 315 deg. Cent. Modifications in the form of the curve were studied by testing the same steel after it had been tempered at different temperatures.

Rheotropic Embrittlement

In Fig. 3 there is a continuous lowering of ductility producing a normal embrittlement, $\Delta\epsilon_1$, at −196 deg. Cent. In Fig. 4, superimposed on the continuous lowering of ductility $\Delta\epsilon_1$ there would appear to be a further lowering $\Delta\epsilon_2$ which is referred to as "rheotropic embrittlement" on account of its response to the effect of plastic flow in the prestraining process[5]. To prevent the transition to a low value of ductility a prestrain of about 0·25 (i.e., a reduction of area of about 22 per cent) was required. As the tempering temperature

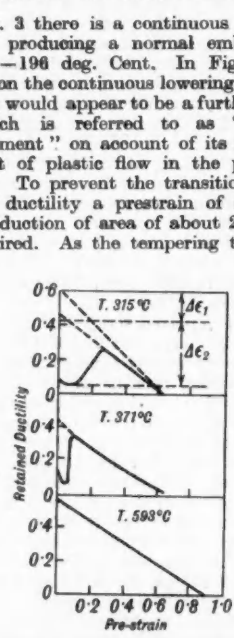


FIG. 4—*Effect of Tempering Temperature and Prestraining at Room Temperature on the Retained Ductility at −196 deg. Cent. of Oil-Hardened and Tempered Steel Containing Carbon 0·42, Manganese 1·81 per Cent. (Ripling and Baldwin)*

was increased, the room-temperature prestrains necessary to secure a stable behaviour at a low temperature became less until, after being tempered at 425 deg. Cent., the material which had had no prestraining was stable down to −196 deg. Cent. With tempering temperatures of 260 deg., 315 deg. and 371 deg. Cent. rheological embrittlement accounted for nearly two-thirds of the decrease in maximum natural strain. The effect of testing temperature on the ductility of the carbon-manganese steel of Fig. 4 in unnotched tensile specimens is shown in Fig. 5. In the usual V-notch Charpy test the transition temperature of the steel tempered at 593 deg. Cent. was −75 deg. Cent., and was progressively higher for lower tempering temperatures. The effect of testing temperature on the ductility of the same steel tempered at 371 deg. Cent. and prestrained various amounts at room temperature is shown in Fig. 6. A prestrain of about 10 per cent or more appeared to depress the transition temperature to below −196 deg. Cent.

The interpretation put on the phenomenon by Ripling and Baldwin is that at low temperatures slip is confined to a few planes so that capacity for slip is exhausted before any large deformation can occur. By straining at room temperature slip is initiated on a large number of planes which can then participate in deformation at low temperatures. As still greater prestrains are used, the main effect is produced by the exhaustion of ductility under the pre-

straining stress, and the normal linear decrease of the remaining ductility with increasing prestrain is observed.

As a comment on this explanation it may be recalled that plastic deformation readily occurs at low loads in overstrained material and that elastic recovery from overstrain is slow at room temperature and below in the steel investigated. It would therefore have been of interest if, for comparison, the low-temperature tests had been made on steel which had been heated at 150 deg. to 200 deg. Cent. after prestraining.

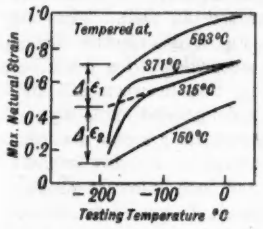


FIG. 5—*Effect of Testing Temperature on the Ductility of the Steels in Fig. 4 (Ripling)*

It seems very probable that such intermediate treatment would have destroyed the strain-curable character of the low ductility.

The effects described above were observed in unnotched tensile test pieces, and Ripling and Baldwin also carried out some work to ascertain how this type of embrittlement is revealed in tests on notched specimens. They prestrained the same carbon-manganese steel, oil hardened and tempered at 315 deg. Cent., in an unnotched condition at room temperature. A 60 deg. V-notch was then machined in the specimens and they were tested to failure, again at room temperature. This straining technique increased the notch ductility of the steel from less than 0·5 per cent at zero prestrain to 2·5 per cent at a prestrain of about 30 per cent. This sort

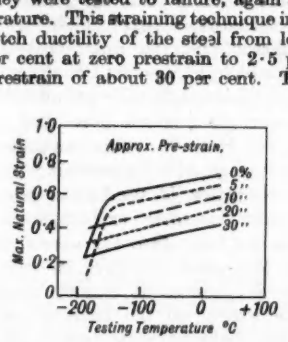


FIG. 6—*Effect of Testing Temperature and Prestraining at Room Temperature on the Ductility of Steel Containing Carbon 0·42, Manganese 1·81 per Cent, Oil Hardened from 830 deg. Cent. and Tempered at 371 deg. Cent. (Ripling and Baldwin)*

of increase can only be expected if the transition temperature of the material lies below room temperature in the unnotched, and above room temperature in the notched condition. Rheotropic embrittlement, in fact, only becomes evident if the material is prestrained above, and tested to failure below, the transition temperature.

A tentative suggestion is made by Ripling and Baldwin[3] that "there may be some practical applications for using strain as a method of overcoming the rheotropic impediment," though "it is not as yet known whether the large fraction of the ductility deficiency at low temperatures" ($\Delta\epsilon_2$ in Figs. 4 and 5), "caused by the rheotropic embrittlement, can be overcome by some simple treatment," involving cold work.

REFERENCES

[1] E. J. Ripling, "Sub-Zero Properties of Metal Surveyed," *Iron Age*, 1950, Vol. 166, October 19th, page 76, and October 26th, page 53.

[2] G. W. Geil and N. L. Carwile, "Tensile Properties of Ingot Iron at Low Temperatures," U.S. National Bureau of Standards, *Journal of Research*, August, 1950, Vol. 45, page 129.

[3] E. J. Ripling and W. M. Baldwin, Jr., "Rheotropic Embrittlement of Steel," American Society for Metals, Annual Convention, 1950, Preprint No. 24.

[4] E. J. Ripling and G. Sachs, "The Effect of Strain-Temperature History on the Flow and Fracture Characteristics of an Annealed Steel," *Journal of Metals*, 1949, Vol. 1, page 78.

Defects in Hot-Rolled Steel

A WELL-ILLUSTRATED account of defects which may occur in hot-rolled steel has appeared in *Stahl und Eisen*.[1] The sources of the various defects are clearly differentiated into three groups. The first group consists of those defects which originate from the initial condition—both physical and chemical—of the material rolled. They include shrinkage cavities and blowholes, giving rise to "piping" and rokes; segregation, banding and non-metallic inclusions; and hair-line cracks, which, the authors claim, can be welded up again by further rolling. Group II consists of defects which arise owing to faulty handling of the steel during the rolling operation, and includes defects caused by unsuitable thermal conditions—for example, decarburisation, surface burning giving rise to cracks, or very coarse grain size due to a high finishing temperature. They also include seams due to the overlapping and rolling in of fins, the decarburised surfaces of which weld up enclosing oxide derived from the original surface. This second group also includes the rolling in of foreign matter, and dimensional irregularities due to defects in the rolls themselves, in their bearings, mountings or other accessories. The third, and last, group includes defects, such as red and hot shortness, which can be avoided by employing proper conditions of temperature in rolling. This type of defect was illustrated by the behaviour of Armco iron, which cannot be worked at 800 deg. to 900 deg. Cent. without producing cracks.

These defects are illustrated by fifty-four photographs which are described in the text in such detail as to conform with the authors' expressed desire to facilitate their avoidance not only in rolling, but also in other forms of hot work applied to steel.

Steam in Heat-Treating Atmospheres

MOISTURE has long been regarded as the most important source of the hydrogen absorbed by steel during melting. Moisture as a source of hydrogen absorbed by solid steel during heat-treatment is less generally recognised. Nevertheless, the subject deserves attention as water vapour is a product of combustion in oil and gas-fired furnaces and may therefore be an important component of commercial heat-treating atmospheres. Damage to the ductility of steel, heat-treated in an atmosphere rich in water vapour, may be considerable; though the only effect commonly considered is the oxidation produced. It is true that the film of oxide formed simultaneously with the absorption of hydrogen in the initial stage of the reaction tends to retard further hydrogen absorption, so that the total effect is much smaller than that of a hydrogen atmosphere; nevertheless, it has been clearly demonstrated.

The work of C. A. Zapffe and R. L. Phebus* has shown that hydrogen derived from steam in heat-treating atmospheres may have a severe embrittling effect on stainless steel. Ductility was measured by means of bend tests on ½in round bars, bent round a pin of the same diameter. Low-carbon stainless steels (carbon 0·1, chromium 12·5 per cent) quenched from 1000 deg. Cent., bent 180 deg. after treatment in air, but fractured on bending only 20 deg. after similar heating in an atmosphere of steam. A steel with the same carbon and chromium contents but with 1·75 per cent of nickel, showed a similar difference in bend values after heat-treatment at 900 deg. Cent. in air and in steam. It could be hardened from 1000 deg. Cent. in dry helium without loss of the 180 deg. value, but fractured at 30 deg. after an air treatment and at only 10 deg. after a steam treatment at the same temperature. Steel with carbon 0·15, chromium 16·3, and nickel 1·86 per cent showed excellent ductility, as measured by the bend test, when treated in the absence of moisture, but was readily susceptible to fracture when exposed to moisture during heat-treatment. A higher temperature was necessary to produce a given effect by moisture, possibly owing to the smaller proportion of martensite produced by quenching, or to a protective action of the higher chromium content.

A high-sulphur free-machining stainless steel (carbon 0·1, chromium 13·0, and sulphur 0·25 per cent) showed less ductility in all specimens, but the bend values of specimens treated in an atmosphere of steam were always well below those of specimens treated in air. High-carbon stainless steel (carbon 1·0, chromium 16·9 per cent) whose bend value in the hardened condition was always low (15 deg. to 20 deg.) because of the high carbon content, showed values as low as 5 deg. when heat-treated in steam. The sensitivity of other hardenable steels to the action of steam in the heat-treating atmosphere can probably be interpolated between the values given by the high-carbon and the low-carbon varieties of stainless steels examined by the authors.

In most furnaces used for hardening and heat-treating steels the atmosphere contains some water vapour and there are indications that even the moisture present as humidity of the air may have some damaging effect on the ductility of the steel.

[1] P. Grüner and T. Brüggemann, "Sources of Defects in Rolling," *Stahl und Eisen*, January 4 and 18, 1951, pages 20 and 71.

* C. A. Zapffe and R. L. Phebus: "Embrittlement of Stainless Steel by Steam in Heat-Treating Atmospheres," American Society for Metals, Annual Convention, October, 1950, Preprint No. 25.

The Effect of Hydrogen on the Ductility of Cast Steel

IN a paper published some years ago by C. E. Sims, G. A. Moore and D. W. Williams,[1] data were given to show that a hydrogen content of 0·3 relative volumes (0·00033 per cent by weight), existing at the centre of cast steel bars 4in square in section, could be reduced, by ageing at 400 deg. Fah. (204 deg. Cent.) for 125 hours, to 0·04 R.V. at which value hydrogen evolution stopped. At the same time the elongation, originally 8 per cent, rose to 22 per cent. In 1in diameter bars of the same heat, the hydrogen content fell to a minimum of 0·03 R.V. after 180 days at room temperature, while elongation rose from 14 to 23 per cent and reduction of area from 22 to 40 per cent. In neither case was there any favourable change in ductility until the hydrogen content had been reduced to 0·1 R.V. Specimens of the 4in square bars were aged at room temperature for eighteen months. At the end of that time the hydrogen content at the centre had fallen to 0·13 R.V. with no appreciable improvement in ductility, and it was estimated by extrapolation that over two years would be required to reduce the hydrogen to 0·1 R.V. and give some significant recovery of ductility.

Three of the 4in square bars have been given a more prolonged ageing at room temperature and the results have been reported by C. E. Sims.[2] After 1310 days (about three and a half years) the hydrogen content had fallen to 0·096 R.V. and the ductility had shown considerable improvement; the elongation had increased to 17·7 per cent and the reduction of area from 16 to 27·5 per cent. The original suggestion that two years at room temperature should result in a considerable improvement, and about three years in complete restoration of ductility, was an under-estimate. It now appears that about six years may be required to reduce the hydrogen content to a minimum value and to restore, at the centre of a 4in square bar, the full ductility which could be attained by heating for five days at 400 deg. Fah. (204 deg. Cent.).

The treatment of carbon steel castings recommended by the authors is ageing at a moderate temperature followed by normalising.[1] The values of elongation and reduction of area so obtained were always greater than those of normalised, or normalised and aged specimens.

[1] "Metals Technology," October, 1948, THE ENGINEER, March 25, 1949, page 329.

[2] *Journal of Metals*, November, 1950, page 1321.

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ECONOMICS OF HYDRO-ELECTRIC DESIGN

IT is generally conceded that in a choice between hydro-electric and thermal power generation a hydro-electric installation is to be preferred when the costs of the two methods show little difference. But when the question of comparing costs is examined in detail it is found that a precise comparison, taking account of all relevant factors, is very difficult to make. In particular the economic evaluation of hydro-electric projects is complex, and it is not always possible to deduce accurately the most economical solution to all the problems encountered. A paper recently presented at the Institution of Civil Engineers, abstracts from which appear on page 262 of this issue, reviewed some of those problems, and the discussion which followed indicated the interest shown in them, and the need for the development of a uniform treatment for the comparison of different projects.

The early stages in the design of a hydro-electric scheme are concerned with the estimation of storage and installed capacity. But any decision taken on those two main factors must, of course, be influenced by structural costs and by the market value of firm power and of "spill" units, and of peak load generation; and the study of the structural costs of the project may in itself be a lengthy and complicated task. In the case of a dam, for instance, it may be straightforward to compare the relative costs of different designs; in examples given in the paper and the discussion, at a particular site the ratio of cost for a round-headed buttress dam, a solid gravity dam and an arch dam was 1·0 : 1·88 : 2·32, and in another case a ratio of 1·0 : 1·2 : 1·66 was obtained for a buttress dam, a gravity dam and a rock-fill dam respectively. These ratios are, of course, influenced by the topography and geology of the site, factors such as a narrow valley and hard rock formation, for instance, favouring an arch dam, and an abundant supply of rock with the consequent absence of quarrying costs favouring a rock-fill structure. But in comparing these costs and in choosing the type of dam to be adopted it must be borne in mind that the safety of the structure is of paramount importance. Furthermore, variation in storage or in available head for different heights of the dam may also have a very considerable influence on costs. In the case of pipe-lines and tunnels it is generally possible to arrive at an optimum economic size, as is indicated in the paper. But the calculation may in some cases be somewhat tentative and depend upon factors which are not exactly ascertainable and some rule-of-thumb solution must then be adopted. Transmission costs from a source of power remote from the centres of consumption may also prove an important economic factor in hydro-electric construction, as also may the attainment of the best operating efficiencies, involving the optimum use of storage capacity throughout the year, and the attainment of the maximum efficiencies for the machines themselves by their correct grouping at any given load. However, apart from such technical considerations as those outlined above, it is clear that economic studies also depend upon factors such as rates of interest and labour costs, which are likely to be variable over the years. The different conditions prevailing in different countries or in the same country at different times may therefore govern the conclusions which are reached as to the financial soundness of a scheme as a whole, or of any particular part of it. For instance, in Great Britain an unlined tunnel, according to Mr. Roberts, proved slightly more expensive to construct than a lined tunnel of the same capacity, thus reflecting the high cost of labour and the comparative cheapness of cement.

A comparison of thermal and hydro-electric power schemes depends upon many such variable factors and is complicated by the fact that the running costs of thermal power stations form a substantial part of the expenditure, whereas for hydro-electric generation the great majority of the expenditure is accounted for by the capital cost. At first glance it might be supposed that the increased cost of coal favours generation of power by water. In fact, the increased cost of coal has not been greatly to the benefit of hydro-electric development, for although water is as cheap to-day as before the war, increased coal prices are reflected in the prices of constructional materials, and the cost of labour has increased as well. The cost of constructing a hydro-electric scheme before the war, according to a contributor to the discussion, was between £25 and £35 per kilowatt of installed capacity; the corresponding cost for a steam station was about £15 per kilowatt. To-day it costs from £80 to £120 for each kilowatt of hydro-electric power installed and from £50 to £60 per kilowatt for thermal energy, showing about a fourfold increase in both cases the ratio of capital costs remaining much the same. It remains, in fact, as complex as ever, where a choice is open, to determine the respective economic merits of generating power thermally or hydro-electrically. It is true that one factor appears especially to favour the latter. That factor is the falling real value of money, a fall that has been continuing irregularly in most, if not all, countries for well over a century, and which necessarily favours methods of power generation where running costs are relatively low and capital costs relatively high. But it is not a factor open to exact calculation; nor is it safe to assume that the same trend must continue indefinitely into the future. Furthermore, it is a sad fact—and one of which Mr. Roberts made mention—that inefficient usage of the generating plant, so that more water is used than necessary, may vitiate to some extent calculations made on the basis that the operating staff will use the plant skilfully. In fact, when a choice is possible it cannot necessarily be made wholly on the basis of economic calculation which may prove inexact. Judgment, also, may be called for.

MATERIALS AND MEN

IT is a trite observation that we are greatly beholden to the accomplishments of our metallurgical and other research workers in determining not only the strength of materials but in ascertaining with scientific accuracy all sorts of characteristics, such as the fatigue strength, coefficient of linear thermal expansion, hardness, density, electrical resistivity, strength to weight ratio, &c. Their labours have enabled us to assess the properties of various alloys with a degree of certainty which admits of very small error. Reference to the simple deductions made long since by such as Rennie and Tredgold respecting the properties of cast iron and wrought iron will show how vast has been the progress in exploring the physical characteristics of engineering materials and in making known the influence not only of ingredients, but of manufacturing techniques. The literature of materials testing discloses, moreover, the great influence of an exact knowledge of materials upon success in machine construction. For example, we know that where machine parts operate below their

fatigue strength they are immune from failure so long as the material is ductile and provided there are no sharp and rapid discontinuities. As we thus contemplate the immense and fruitful attention which has been given to machine design, metallurgy, and to the conditions affecting the safety of component parts, it will be borne in on us how trifling, in comparison, is the attention which has been paid to the human material. If a margin of safety is requisite in materials it is requisite also in men, since a man who has no working margin may be compared to a weak test-piece: he fails at a low stress.

Whether he be an executive or a machinist, a man's true value is measured not so much by the work which he actually accomplishes as by the work which he can be relied upon to accomplish should the emergency arise. It is, indeed, a proverbial saying (almost universally disregarded) that what a man gives out in real work returns to him in character, and one of the major dangers of our time is that men—and we speak here of men in all categories—do not sufficiently appreciate the fact that without conscientious activity there can be no progress; indeed, does not Nature itself set a curse on inactivity? We shall not be wrong in affirming that whether he be employed in manufacturing industry or in any other field of effort, the worth of a man is represented by the difference between what he actually does and what he must do. This does not mean that men shall work at an intensity beyond that at which they can work efficiently: fatigue strength applies to men just as it applies—for example—to ductile steel. But there exists in all real men something of that capacity which the poet Burns had in mind when he remarked in his epistle to Dr. Blacklock, that:—

> "Wha does the utmost that he can
> Will whyles do mair!"

It is this sort of man to whom we are indebted for that position in the world which we now stand in danger of losing and the main object of all our endeavours must be to create an atmosphere in which work is recognised as the noble thing it is and loafers are exposed for the parasites they are. If there has been a vast scientific development in respect of inanimate materials there has also been a great change in the relationship between what is called labour and what is called management, though both, properly considered, are essential organs of the same body. The old order has changed and we have now reached a stage when the machinery used in trade disputes stands in need of overhaul. For, with public ownership of the coal, transport and other industries, a drastic alteration has taken place in what may be called the "climate" of employment in those industries. Any agitation in such industries must now be directed not against private individuals or corporations, but in effect against the Government itself, so that the old type trade union has lost a great part of its *raison d'être*. Following upon nationalisation or "socialisation," conflict with private ownership ceases; but the workers in "socialised" industry have to accustom themselves to a kind of ownership in which the human aspects are being replaced by something comparatively impersonal. It is as if a football team should be led not by a captain in the field but by a committee—not necessarily of football players—sitting somewhere out of sight! This arrangement would certainly be disastrous in sport and it has yet to be established that it can win games in industry. Never in our industrial history has there been more imperative need than now for harmony based on realisation of the fact that wounds delivered by either side are mutually injurious to both. That human behaviour is now being made the subject of well-endowed study in the United States indicates a belated recognition there of the fact that technical progress has far outstripped the development of that deeper human intelligence without which true progress is impossible. We have referred above to that quality of ductility which is so valuable in certain machine parts subjected to heavy stresses. We sorely need this quality in human relations and the great difficulty is to get the idea over to all those who are engaged in the nation's work—which means everybody. We must have harmony in industry and we should labour to create the atmosphere wherein work may become something which is recognised as desirable and honourable in itself. Perhaps we have the key in the word "diligence," which is from the Latin "diligo," to love. Unless we can love our work we shall not succeed in our endeavours, no matter what may be the activity in which we are engaged.

Obituary

HARRY PARSONS

We record with regret the death of Mr. Harry Parsons, J.P., M.I.Mech.E., which occurred, after a short illness, on February 17th, at his home at "Brampton," Bassett Avenue, Southampton. He was particularly well known in the British internal combustion engine industry as the founder and chairman of the Parsons Engineering Company, Ltd., of Southampton.

Harry Parsons was born in 1871, and was educated at Andover and Brighton Grammar Schools. At the age of sixteen he began an apprenticeship with the engineering firm of J. and F. May, High Holborn, London, on whose staff he remained for a year or so after his apprenticeship was completed. In 1893, however, he decided to start business on his own account in London as a mechanical and general engineer, but a couple of years later he disposed of that business to take up an appointment in 1895 with Rudge Whitworth and Co., Ltd., of Birmingham and Coventry, where for the next two years he had charge of the design department. Parsons continued to work in the Midlands for a few years thereafter, becoming successively works manager of the Beeston Cycle Company, Ltd., Coventry, and works manager of the Premier Cycle Company, Ltd. He returned to London in 1901, when he was appointed designer and works manager of the Motor Traction Company, Ltd., taking a special interest in the development of the motor-cycle.

It was in 1904 that Mr. Parsons decided to establish the firm with which he was actively associated for the remainder of his life. In its early days the firm was known as the Parsons Motor Company, its main business being the production of paraffin engines patented by its founder. In the years which have followed, the company, through Mr. Parsons' energy and ability, has progressed to an important place in the marine and industrial oil engine business. In addition to his work for his company and for the oil engine industry Mr. Parsons was active in many other directions. He was a past-president and honorary director of the Southampton Chamber of Commerce, a vice-president of the Association of British Chambers of Commerce, and for twenty-one years, from 1923 to 1944, served as chairman of the Southampton Harbour Board. He was also a Justice of the Peace. Mr. Parsons was elected to associate membership of the Institution of Mechanical Engineers in 1898 and to full membership in 1914.

R. C. STANLEY

We have learned with regret of the death of Mr. Robert Crooks Stanley, chairman of the International Nickel Company of Canada, Ltd., which occurred on February 12th, at his home at Staten Island, New York. Mr. Stanley, who was seventy-eight, had been associated with the International Nickel Company since its formation in 1901. Robert Stanley was a mining engineer by profession, and he entered the nickel industry as assistant superintendent of one of the production units, where his energy and ingenuity attracted early attention and led to quickly increasing responsibilities, first in the operational and later in the administrative field. He became president of the company in 1922, when the industry was in a very depressed condition, and one of his first, and more outstanding, achievements in that office was to organise a vigorous programme of scientific research, designed to bring nickel to the service of mankind over the widest possible field.

During his term as president Mr. Stanley was one of the principal authors of the merger with the Mond Nickel Company, in 1928, resulting in the present International Nickel Company of Canada, Ltd., an enterprise which, it is estimated, supplies three-quarters of the world's annual requirements of nickel. Mr. Stanley resigned the presidency two years ago, but up to the time of his death he was chairman of the board, an office to which he was first elected in 1937. He will be greatly missed by a wide circle of friends in the United Kingdom, Canada, and the U.S.A.

Literature

Jane's Fighting Ships, 1950–51. Edited by R. V. B. Blackman. London: Sampson Low, Marston and Co., Ltd., 25, Gilbert Street, W.1. Price £3 3s.

The publishers of "Jane's Fighting Ships" are to be congratulated on the improvement in the lay-out of the pages of the new edition. The essential particulars of a ship required in a work of reference—dimensions, armament, machinery, &c.—have been collected together and are now tabulated in vertical sequence, followed by the less important details and explanatory notes, in one compact column. The various ships of a class have been arranged, with their names in prominent black type, in columns, and the drawings and photographs are displayed in an ordered pattern throughout the book. The new lay-out, which makes for quick and easy reference, has necessitated the addition of eighty pages to compensate for the reduction in the number of photographs on each page. Most of the pre-war and wartime photographs have been replaced and this new issue presents some 500 fresh illustrations—altogether a remarkable achievement.

A notable change, more open to criticism, is the presentation of aircraft carriers before battleships in the order of

categories. In a Foreword, the publishers explain that the newly won precedence of aircraft carriers in "Jane's" is the culmination of a long and slow progress, and they emphasise that the larger aircraft carriers have drawn level with battleships in size, complication of construction and cost, and have overtaken them in engine power. All except one of the British and United States battleships, they add, have been placed in reserve and, whereas the United States and Britain had only five and seven carriers respectively before the war, the United States now maintains 103 and Great Britain 13.

The important part which the carrier now plays in sea warfare cannot be too strongly emphasised, but the reasons given for placing her first in the order of categories are far from convincing. If size is to be the deciding factor in judging the relative importance of ships, a page might well have been included giving pride of place to the "Queen Mary," which was used as a troop transport during the war. Equally, if numbers are the main consideration, destroyers and even frigates should have precedence. The essential criterion is, of course, the function of a ship and the battleship is still at the present day the ship on which all others—the carrier, the cruiser and the destroyer—must ultimately fall back for support if there are enemy battleships in the vicinity. The battleship is still to-day the most powerful ship afloat, offensively and defensively. It is only because the British and United States naval authorities do not credit the Russian Navy with a battleship force worthy of the name that they have been able to place in reserve practically all their own vessels of this type. "Jane's Fighting Ships," it must be remembered, is not only a standard work of reference. It is also a guide, philosopher and friend to all those civilians who are seeking to learn the meaning and value of sea power, and on this ground alone naval circles will view with regret the relegation of the battleship to second place.

Since the Royal Navy—in common with the other fighting Services—is now concentrating on preparations to meet Russian aggression, it seems curious, particularly in view of the priority of place given to carriers, that no mention is made of the 23,000-ton Russian-built carrier to which "Jane's" 1949–50 edition referred as "probably now in commission." Indeed, the sole reference to Russian carriers in the new edition appears in the Foreword—a brief sentence intimating that "there is no confirmation that Russia is to build three aircraft carriers of 25,000 tons." The point is of considerable importance in relation to the statement made in this year's edition that "the construction of one to three battleships of a new powerful type in Russian dockyards is persistently reported." In the Foreword we are even given reports of their armament and equipment, and of one being in commission, another launched and the third still on the stocks, and further particulars are given, with reserve, in the addenda. These are much firmer and more positive statements than appeared in last year's edition, which did not go beyond "conflicting reports, given with all due reserve, of one to three battleships in commission or about ready for commissioning." For what purpose are these ships being built? "Jane's" is concerned only with technical details, but when the strategical or tactical aspect of sea warfare has a direct bearing on the number and types of ships likely to be built by a potential enemy, the editor might well have been excused if he had referred to it to comment on the degree of accuracy to be attached to these reports. Under modern conditions battleships cannot operate in the open seas without the support and co-operation of carrier-based aircraft, and it seems inconceivable that Russia would be building these costly monsters only to operate them as floating batteries, within range of her shore-based fighter aircraft.

The publishers do well to emphasise in their Foreword the evidence of Russia's maritime awakening at a time when the British people are preoccupied with the inadequacy of their Army and Air Force. For the civilian is inclined to forget that he can be starved as well as bombed. The capacity of Soviet shipbuilding, we are told, which is at the present time largely supervised by German specialists and bolstered by foreign labour, is reported to be twice that of ten years ago, and we are reminded of the significance of the Russian Navy now being under its own independent Ministry of Marine, whereas the Army and Navy still remain under the orders of the combined Ministry of Armed Forces. The Russian section begins with the alleged and fabulous new programme of construction which includes three battleships (presumably those referred to above), 20 cruisers, 120 destroyers and 1000 submarines. Our chief interest at the moment lies in knowing the number of Russian submarines and these "Jane's" gives as not fewer than 350–370 in service, with another 120 reported as under construction. There seems no reason to question these figures, though high-ranking United States naval officers (who are less reticent than our own!) estimate the number in service as about 280. But this figure no doubt excludes the "many older vessels" which, according to "Jane's," "are used for training purposes." The only other point of submarine interest appears in the United States section in which reference is made to two new types of submarines projected, one driven by atomic power and the other by a closed-cycle engine, using hydrogen peroxide. No attempt has been made to obtain details of these vessels, which are kept top-secret in the United States.

Finally, "Jane's" would do well in future editions to reduce the number of types of destroyers. To the naval officer who has lived with the destroyer since she replaced the torpedo boat, a destroyer remains a destroyer, irrespective of her size or armament or whether special importance is attached, in one as compared with another, to her anti-submarine duties. In the British section of this year's edition there are no less than five different names given to destroyer types: large fleet destroyer, fleet A/S escort, fleet A/S destroyer, fleet destroyer, and destroyer. This note of criticism, however, in no way detracts from the great value of the 1950–51 edition as a reliable reference book on the world's navies. The editor, indeed, is to be congratulated on producing a comprehensive work of this nature, with such a mass of detail, in view of the secrecy which all great naval Powers are now maintaining over the constructional details and equipment of their ships, building or projected.

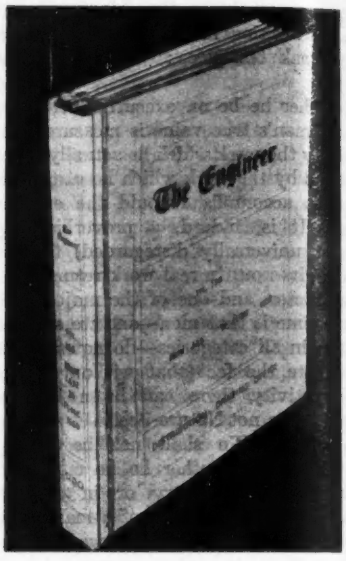
Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

BINDING "THE ENGINEER"

SIR,—Your readers may be interested in the method which I recently adopted for binding volumes of THE ENGINEER. Several years' accumulation stacked in this office was liable to be disposed of as waste paper, when I undertook to bind them. The foundations for the covers were old "Roll Arch" files with the metal parts removed. These were cut so as to include the natural fold ⅛in from the edge.

A negative was prepared on tracing paper, 40in by 27in, for the front and back covers, a backing strip and two flyleaves. Underexposed dye-line prints were obtained from this negative. The effect of under-exposure is to produce a pleasing mottled background. The front and back portions were pasted on to



the foundations, the interior surface of the file becoming the exterior of the cover so that the natural fold folded outwards. Using a template, six holes were punched in each part, with the advertisements removed. The covers, flyleaves, folded backing strip and index were similarly punched. The whole was assembled and laced together with stout string.

The completed volumes, as illustrated, present a uniform appearance, and are much more convenient for reference than separate parts.

J. D. HARRISON

Distribution Drawing Office,
Metropolitan Water Board,
London, E.C.1

[The method of binding described by Mr. Harrison will certainly be of interest to many readers who have similar accumulations of copies of THE ENGINEER. His letter gives us the opportunity to point out to others not willing to take as much trouble as he that, if approached, we can make arrangements to have such accumulations bound into complete volumes by more conventional methods.—Ed., THE E.]

ENGINEERING INSTITUTIONS

SIR,—The idea underlying the suggestion put forward by Mr. Elkan to the effect of merging engineering institutions surely strikes at the root cause of the comparatively poor status of the professional engineer.

The problem is, however, much broader than the mere amalgamation of the three major engineering institutions.

First, I would submit that one Institution (the "Civils") does already cater for nearly all branches of engineering, and, secondly, that minor institutions will always exist for those whose qualifications do not fit them for membership of the senior institution.

In the May issue of the *Journal* of the Engineers' Guild, I, too, appealed for unity within the profession as a vital preliminary to the attainment of the Guild's aims and objects.

Falmouth, February 3rd. C. P. GOODWIN

The Aviation Engine*

By Air Commodore F. R. BANKS, C.B., O.B.E., M.I.Mech.E.†

No. I

THE new era of aviation may be said to have started with the first flight of the "Gloster" E28/39 aircraft fitted with a Whittle jet-propulsion gas turbine, on May 15, 1941.

Actually, the first flight ever made with a jet-propulsion gas turbine engine was that of the German Heinkel "178" machine, in August, 1939; but this had not, apparently, the early impact upon the German aviation industry as had the British effort on the industry in Britain, although it was due largely to the Ministry of Aircraft Production that the pace was forced, since the engine firms were already loaded almost to the limit of their development capacity, to meet war needs.

The aviation gas turbine, because of its characteristics and peculiar limitations, has altered the parameters of aviation, and some years must elapse before a completely clear view is possible in the new and advanced field of aerodynamics and engineering opened up by this prime mover.

It should not be forgotten that the success of the aviation gas turbine, and the swiftness of this engine's practical development and application in the world of flight has been due largely to the specialised engineering technique built up by those who have devoted the best part of their lives to the advancement of the piston type of aviation engine.

There are three distinct types of aviation gas turbine. The first is the jet-propulsion unit or turbo-jet, in which all the air for combustion and propulsion passes through the engine. The second is known as the ducted-fan engine, which is a turbo-jet incorporating a multi-bladed turbine type of fan or propeller enclosed in a duct. This fan can be located in front and ahead of the main engine compressor, driven by gearing, so that it takes a proportion of the air and passes it through a separate duct surrounding the engine proper, the rest going through the engine in the normal manner. Conversely, it can be an integral part of a free turbine located behind the main turbine which drives the compressor. But this latter arrangement makes the engine awkward to install and, unlike the former type, it does not provide the engine compressor with any additional "ram."

The third type is the propeller turbine, in which the ratio of turbine to compressor size is such that sufficient power is available to drive a propeller in addition to that absorbed by the compressor.

In all three types the propulsive efficiency is highest when there is least difference in speed between their respective "discharges" and the speed of the aircraft in which they are fitted. This assumes that efficiency is assessed on a basis of change of kinetic energy, where input per pound of air flow is equal to the jet or discharge kinetic energy less the kinetic energy of forward speed:

$$\left[\frac{V_j^2}{2g} - \frac{V^2}{2g}\right] \quad . \quad . \quad . \quad . \quad (1)$$

where V_j is jet velocity and V is aircraft velocity, both expressed in feet per second.

The ducted-fan engine falls between the turbo-jet and the propeller turbine, in that it offers improved propulsive efficiency over the turbo-jet at take-off and climb and at all speeds below about 650 m.p.h.

It is impracticable, within the scope of this lecture, to discuss all the possible applications of these three engine types and how one may overlap the other in meeting particular aircraft requirements.

The turbo-jet has already taken the place of the piston engine in fighters and also in light bomber aircraft, such as the English Electric "Canberra." It also has application in the passenger transport field, the De Havilland "Comet" being the first practical example.

The propeller turbine has a wide field of application, but its potentialities do not yet appear to be fully appreciated, probably because the turbo-jet has caught the imagination owing to its apparent simplicity of installation and lack of mechanical complexity.

Civil aircraft of medium size, between 50,000 lb and 60,000 lb all-up weight, having four propeller turbines totalling 4800 e.h.p. or 6000 e.h.p. (equivalent horsepower, that is, shaft power plus jet thrust), can give economical operation in the range of 400 to 600 miles; whereas the operating costs of the equivalent aircraft with turbo-jets would be some 50 per cent higher according to a private communication by Mr. Edwards, of Vickers-Armstrongs. For instance, the former would have a fuel consumption during stand-off at 5000ft, before landing, of about 250 gallons per hour, which figure would be increased to 600 gallons per hour for the turbo-jet installation. At 20,000ft the specific mileage of the propeller turbine machine is about 1·2 nautical m.p.g. and that for the turbo-jet 0·4 nautical m.p.g.

The economics of the turbo-jet aircraft become feasible for a machine of not less than 100,000 lb all-up weight and a stage length (range) of over 1250 miles, since the reserve fuel carried for stand-off purposes is then a more reasonable proportion of the total fuel capacity.

The second application of the propeller turbine concerns large high-speed civil or bomber type of aircraft, having an operating range of between 3000 and 5000 miles in still air, where engines of large unit power—about 10,000 e.h.p. each—would be required.

It was first thought that propeller efficiency would be relatively low at high aircraft speeds, but more recent information suggests that a propeller could now be built having a propulsive efficiency better than 80 per cent at 0·9 Mach number. In fact, it has been suggested that high propulsive efficiencies are possible with propellers designed for aircraft speeds up to Mach No. 1·5.

A propeller to absorb the power of a large gas turbine of, say, 10,000 e.h.p. would be of the multi-blade contra-rotating type, very restricted in diameter, and running at high tip speed. Such a propeller would have blades of very thin section.

It is often erroneously supposed that the propeller turbine is the intermediate step in power plants between the piston engine and the turbo-jet. In fact, it has a place of its own and, if the propeller efficiencies just quoted can be realised in practice, the propeller turbine is seen in quite a different light. An aircraft fitted with propeller turbines should give better all-round flexibility of operation than the turbo-jet machine, with greater latitude or choice of operating height.

There is already, in the United States, a very promising propeller turbine of high power and relatively low fuel consumption. This is the "Allison" T.40, which produces more than 2 h.p. per pound of engine weight—an impressive power/weight ratio. The T.40 consists of two separate (T.38) units, each of 2750 s.h.p. (shaft horsepower, neglecting jet thrust), geared together and driving a contra-rotating propeller through a double-reduction gear ratio of 15·7/1. Incorporated in the gear system is an automatic device to declutch an engine in case of its failure, and so allow the other engine to continue driving the contra-rotating propeller, relieved from the "drag" of the defective unit.

The total weight of the T.40 twin unit is reported to be only 2618 lb, which includes the gearbox and the short extension shafts between the power units and the box.

The single power unit of this engine, the T.38, has a seventeen-stage axial-flow compressor of steel construction, driven by a four-stage turbine, having a pressure ratio in excess of 6/1. There are eight combustion chambers.

The twin T.40 engine is now installed in the "Consolidated" XP5Y-1 flying-boat for the United States Navy, and it is also fitted in prototype Douglas and North American attack bombers. In the "Consolidated" boat a new type of Aero-products six-bladed contra-rotating propeller is used. An experimental installation, with two (single) T.38 units, has also been made in a "Convair" airliner.

The specific fuel consumption of the engine has not yet been disclosed, but is stated to be equivalent to that of a piston engine of comparable power. On this basis, and because the gas turbine cruises at a high proportion of its maximum speed and power, compared with the piston engine which cruises at some 50 per cent of its maximum, the specific fuel consumption should be less than 0·6 lb per h.p. per hour!

Details of another American propeller turbine have just been released. This engine, the Pratt and Whitney T-34, produces about 5700 h.p. in a single unit for a (dry) weight of about 2550 lb, representing a specific weight of less than 0·45 lb per h.p. It is understood that approximately 90 per cent of the power goes to the propeller and the remainder to jet thrust.

The specific fuel consumption is quoted as 0·62 lb per h.p.-hour, which is presumably at or near maximum power, static sea-level conditions.

The respective fuel consumptions of both the Allison and Pratt and Whitney engines are remarkable, particularly when compared with that of a piston engine at equivalent full power output. Since the mixture strength of the latter has to be increased at take-off, a specific fuel consumption of 0·85 lb per b.h.p.-hour and greater is quite usual.

The Pratt and Whitney T-34 engine is also interesting because it is mainly of steel construction, and this does not appear to have imposed any weight penalty.

The T-34 has a thirteen-stage, axial-flow compressor and a three-stage turbine. Appar-

* James Clayton Lecture. Institution of Mechanical Engineers, February 16th. The lecture was divided into two parts. The first dealt with the piston engine and the second with the gas turbine. In the first part, the development of the piston engine was discussed with emphasis upon those factors, such as supercharging and improved fuel, which have particularly contributed to its present high performance. Cooling developments of both the air and the liquid-cooled engine were discussed, and also the influence of such detail refinements as the sodium-cooled valve and sparking plugs having sintered aluminium oxide insulators. We reprint only the second part of the lecture.

† Technical manager and chief engineer of the Associated Ethyl Company, Ltd.

ently, an annular type combustion chamber is used. The engine is 155in in length and has a basic diameter of 30in.

Axial or Centrifugal Compressor

Future development of the turbo-jet and the large propeller turbine will favour the axial compressor, because the never-ceasing efforts further to improve aircraft performance, particularly in the military field, demand still greater reduction in the bulk of all aircraft components; and the axial compressor affords the best opportunity for obtaining high power from minimum dimensions, since it can handle a much larger mass air flow for a given diameter than can the centrifugal compressor.

It was first thought that the axial type of turbo-jet engine would always be the heavier, but this has not proved so in practice, and there are already axial engines in existence of lower weight than centrifugal engines of similar thrust.

The axial compressor is considerably more expensive to manufacture than is the centrifugal; but, to view this in the correct perspective, the production cost of each should be specifically related to engine thrust. The cost of the axial, which is due to its many blades, will not remain at the present high differential, particularly when more is known of its aerodynamics, and the designer has all the information necessary to design a compressor which will readily meet requirements without excessive "trial and error" testing.

The difficulty, so far, has been to design an efficient axial compressor that will give, say, 6/1 pressure ratio in eleven or twelve stages, with flexibility of operation and without surging. It is relatively easy to design and build a compressor which will meet performance estimates, if the number of stages is unlimited and if no restrictions are imposed on length or weight. But, since the whole secret of building a successful aviation engine lies in the ability to reduce bulk and weight, the designer will naturally attempt to get the desired performance and maximum work from the minimum number of stages.

Therefore, until further aerodynamic knowledge is available, "trial and error" tactics must prevail and these naturally take time. To reduce the time factor, which is principally due to the calculations involved in designing new blade forms and manufacturing fresh blades, it is necessary to have in the design office a number of high-level aerodynamicists with good mathematical training and also, possibly, an electronic calculating machine, plus a very efficient pre-production department in the works.

Compressor Efficiency

At present, the adiabatic efficiency of the axial is between 83 and 85 per cent and it should be possible to obtain 87 per cent efficiency in the course of a few years. The efficiency of a well-designed centrifugal compressor is about 77 or 78 per cent, which is also capable of further improvement by 2 or 3 per cent. But the high pressure ratios possible with the axial compressor are very important in relation to overall operating economy.

It is true that the axial compressor is more sensitive and susceptible to dirt and to damage by ice, &c., than the centrifugal, but this will not influence its general acceptance where high economy and performance are concerned.

The centrifugal compressor turbine will however, have a further obsolescence of some years in military aircraft of fairly high subsonic performance and will, probably, continue to be used in those machines designed for short-range low-level operations, such as ground attack. It will also see reasonable length of service in civil aircraft of the "Comet" type, and in the smaller propeller turbines such as the Rolls-Royce "Dart."

(To be continued)

Survey Launch "Ain-Al-Bahr"

AT Bideford, in North Devon, the firm of Grimston Astor, Ltd., has been occupied since the war in producing large numbers of small craft built in light alloy. The underlying principle of the method of construction employed is that of two-way tension, which gives strength combined with lightness. In the early years canoes, dinghies and other small craft were built, but as experience was gained in using the system a more ambitious programme was undertaken. Towards the end of 1949 the "Sea Hawk" model was built, which had a wide range of possible applications. These boats had a length of 26ft, a beam of 7ft 6in, a draught of 1ft 4in, a hull weight of approximately 850 lb and were capable of a speed of 15 knots with a 20 h.p. motor or of 30 knots when fitted with a 75 h.p. motor.

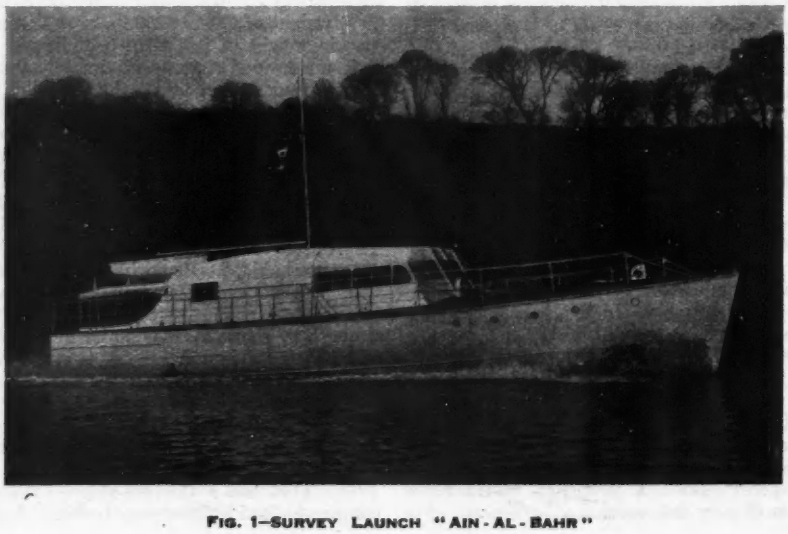


Fig. 1—Survey Launch "Ain-Al-Bahr"

The system breaks away from the traditional method of rolling plates to shape and fastening them to frames already bent to template, and exploits to the full the qualities of strength and lightness combined with ease of working, which aluminium alloy possesses. By forming the hull in this manner and using aluminium alloy, the system enables a hull weight reduction, compared with steel, of some 60 per cent, a saving in weight which is in proportion to the specific gravities of steel and aluminium alloy.

The lightness of the hull leads to economies in many directions. The hull weight reduction can be used for greater carrying capacity or for reducing the displacement so that it is possible to obtain greater speed for the same power or the same speed on less power. For export purposes the prefabricated parts can be packed flat for assembly abroad, and it is estimated that five sets of parts can be transported in this manner for the same freight charges as for one fully assembled boat.

Fig. 2—Fore Peak Bulkhead

Description of Method

The method allows each half of the shell of a boat to be prefabricated in a flat, unstressed condition before being flexed about the centre to form a round bilged hull of predetermined shape. Sheets forming the shell are laid out flat and riveted together, then the gunwales, stringers, engine bearers and bilge keels are fastened to them while still in the flat condition. The transom and former frames are set up next and the prefabricated shell is then flexed upwards from the keel, starting at the stem and working towards the transom.

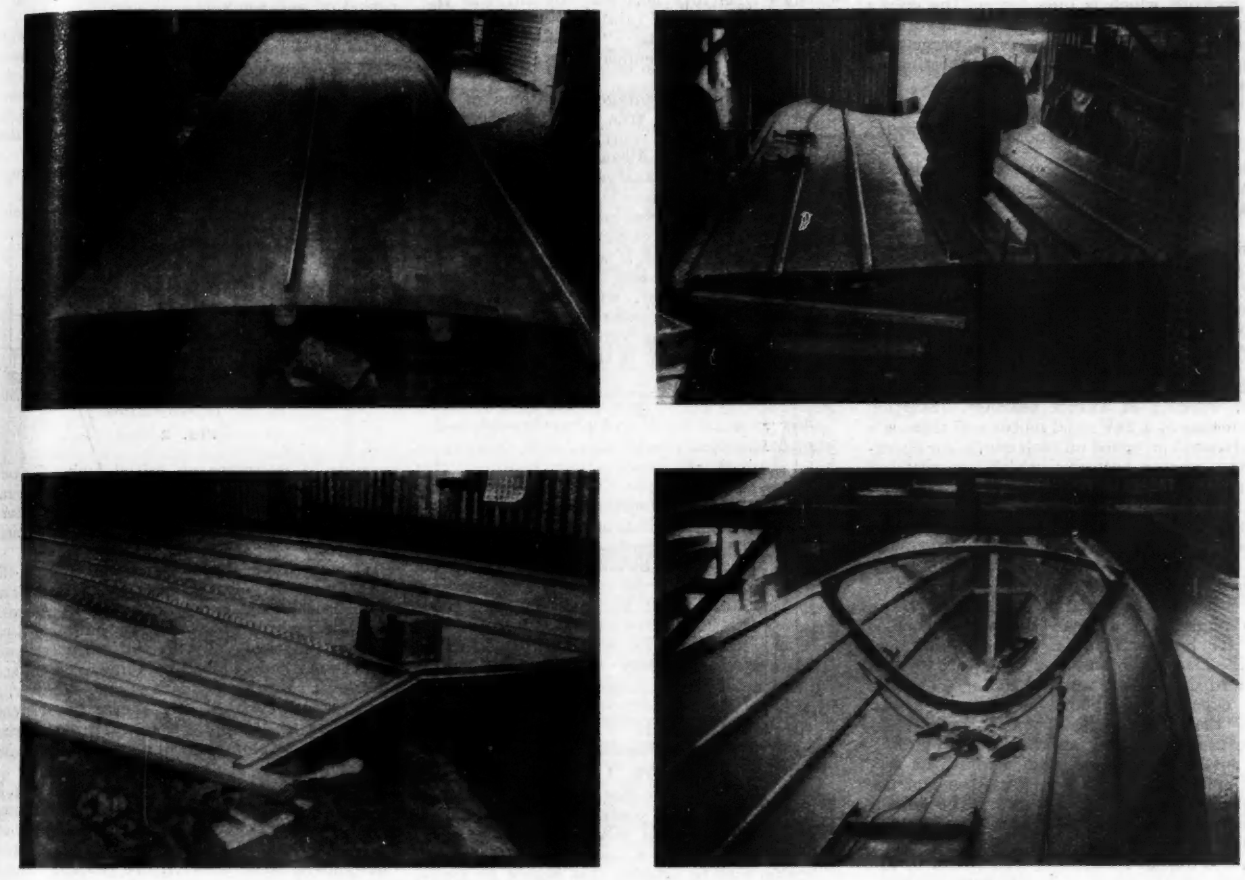
Sheet material when curved in a single direction becomes stiff along the axis of curvature and the introduction of curvature, in another direction, in association with supports to prevent buckling, results in a flexed, drum-like surface. This condition of restrained double curvature gives a springy resilience to the shell by reason of the stored up energy and sheet of No. 16 gauge has been used successfully to form the skin of a 26ft hull.

The accompanying photographs illustrate the two-way tension method of construction. In Fig. 3 the sheets forming half the shell are shown with the gunwale and part of the longitudinal framing already in position. The two halves of the shell can be seen in Fig. 4, being bolted together preparatory to riveting to the keel, the small angles take the engine bearers and are through riveted to the "Tee" section bilge keels. Fig. 5 is a view looking at the fore end of the fully framed skin, which is ready for flexing about the knuckle joint at the keel to form the stem by riveting together

the "Tee" sections. The transom is now placed in position and the skin is wrapped around it and secured by the projecting ends of the upper longitudinal frames, which help reduced displacement increases the GM and makes a stiffer ship.

The shell plating is of No. 10 and No. 12 gauge sheet, and the foredeck plating is of the boat, supported at the ends, recorded a deflection of ½in with a permanent set of ¼in.

As previously stated, the launch is intended for survey work and the specification is very



FIGS. 3, 4, 5 AND 6—STAGES IN TWO-WAY TENSION METHOD OF CONSTRUCTION

to produce the correct curvature and to resist buckling. To withstand twisting strains transverse ribs are now fitted and, in Fig. 6, the shell is shown flexed to shape with a transverse frame in position.

The latest advance made by the firm in using its particular production method is the building of a 60ft survey launch, "Ain-Al-Bahr," for the Pakistan Government and we were able, at the invitation of Grimston Astor, Ltd., to inspect the vessel and to make a trial run. During the trial the launch did one run each way over a measured course, easily exceeding the service speed of 12 knots, and performed a number of evolutions in broken water on Bideford Bar. The boat has an easy motion and displayed excellent sea-keeping qualities. Our photograph shows the launch leaving Bideford for trials.

CONSTRUCTION AND ACCOMMODATION

The launch (Fig. 1) is of considerable technical interest and is built completely of aluminium alloy, which has excellent corrosion resistance properties and, compared with a wooden hull, is not affected by the Teredo worm. The British Aluminium Company, Ltd., has supplied the sheet and section material and has given some technical assistance to the builders. The aluminium alloy used is to standard specification N.5, the main alloying constituent being 3½ per cent magnesium, the sheet being in the quarter-hard condition. The vessel has an overall length of 60ft, a moulded beam of 14ft 6in, a draught of 2ft 9in over the propeller and beaching skegs and a displacement of 11 tons. The height of the metacentre above the centre of buoyancy (BM) is 8·15ft and the metacentric height (GM), with the vessel at rest, gives an easy roll, but when under way the launch begins to plane and the positive grip chequered plating of special pattern. "Tee" sections of 3½in by 3½in by ⅝in by ⅜in form the keel and bilge keels; similar sections of smaller scantling, 2½in by 2½in by ⅝in, are used for the inwales and the gunwales are of 3½in by 2in by ⅛in channels. Rubbing pieces are fitted at points necessary to protect the hull and they are of 2½in by 1½in by ¼in top hat section. Riveting is the principal method adopted for joining, aluminium alloy rivets to specification N.R.6 being used throughout. In the course of its duties the launch will be drawn up on beaches. Therefore to protect the bottom and the stern gear twin skegs are fitted and are combined with the shaft brackets. The material used for the solution heat treated aluminium alloy casting is to specification L.M.10.-W, which contains 10 per cent magnesium. There are four watertight bulkheads. In the photographs, which we reproduce herewith, the general constructional details can be seen.

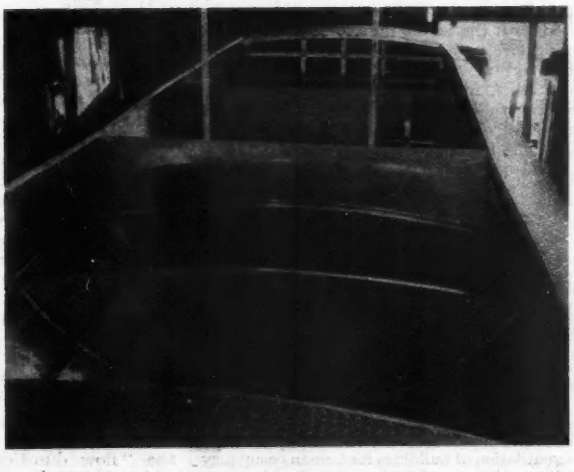


FIG. 7—CONSTRUCTIONAL DETAILS LOOKING AFT

The launch is built to the requirements of and under the supervision of the Ministry of Transport. Although lightly constructed, it successfully passed the strength test normally applied to lifeboats, and with a 20 per cent overload plain. A sliding door to port and a hinged door, fitted with an accommodation ladder, to starboard, give access to the main cabin. This has a raised deck and forms the dining saloon and general living quarters for the survey officers besides having the steering position and chart-table fitted forward to port. Steps at the forward end of the cabin lead down to a door in a water-tight bulkhead, which gives access to the simply furnished officers' sleeping cabin. A door in the water-tight fore-peak bulkhead (Fig. 2), leads to the toilet space and chain locker.

At the aft end of the main cabin a door to starboard opens on to an enclosed passageway, which is fitted out as the officers' galley and also leads to the cockpit aft. The crew's galley is located in a similar passage on the port side, but has access only from the cockpit. The cockpit, which is open, forms the crew's quarters, for whom built-in lockers have been fitted, and overhead there is a permanent awning, upon which are chocks supporting an aluminium alloy dinghy.

Engine-Room

The engine-room is situated immediately aft of the deck cabin and is bounded by watertight bulkheads. Two Perkins direct injection, cold starting, four-stroke, diesel engines, having six cylinders of 3½in diameter by 5in stroke, are provided, each developing 65 b.h.p. at 2000 r.p.m. They are directly mounted on the engine bearers and are not handed. Power is transmitted to the three-bladed light alloy propellers, which have a diameter of 16in and a pitch of 11in, through an oil-operated gearbox and a 1¼in diameter stainless steel shaft, working in Tufnol bearings. Starting is by means of a 24V axial motor and there is a 24V dynamo provided on each engine for charging the starter batteries, which are situated against the aft bulkhead and which have a capacity of 130Ah. The closed circuit cooling water is cooled in an external heat exchanger, which consists of 30ft of ¾in square tube for each engine. A separate pump injects water into the exhaust system.

A Stuart auxiliary diesel engine drives a bilge pump and a small dynamo, which is used for battery charging and lighting purposes. The water and fuel tanks are of one standard size. There are four fuel tanks with a total capacity of about 750 gallons, placed below the main cabin flat and three freshwater tanks, totalling approximately 560 gallons, one in the engine-room against the forward bulkhead, one at the forward end of the cockpit and one in the aft peak. The launch is designed to have an endurance of 1500 miles and a speed of 12 knots.

On the official acceptance trials, held in the presence of Ministry of Transport surveyors, the performance of the "Ain-Al-Bahr" proved to be satisfactory. A mean speed of 13·46 knots was attained and the sea-keeping qualities were demonstrated in a heavy swell on Bideford Bar. During manœuvring trials the rudder was put hard over in both directions, with one engine at full ahead and the other at full astern, and the tactical diameter of the turning circles to port and starboard was approximately 1½ lengths. This manœuvre was repeated with the inside motor idling and gave a turning circle estimated at two lengths.

A companion vessel to the "Ain-Al-Bahr" is being built, in Pakistan, of teak, and it is understood that this craft will have a displacement of about 70 tons, a draught of 4ft 6in and will be powered by engines developing a total of 260 b.h.p.

Codes of Practice

The Council for Codes of Practice for Buildings—Construction and Engineering Services, is under the egis of the Ministry of Works. Codes are issued on behalf of the Committee by the British Standards Institution, 24–28, Victoria Street, London, S.W.1.

VENTILATION

Chapter I (C), "Ventilation," which has now been issued in final form, deals with requirements for the ventilation of buildings for human occupancy in relation to the rate of fresh air supply, air movement, temperature of incoming air, humidity and purity of air. Although the appropriate methods and designs for ventilating systems are dealt with in the General Series Codes, the appendices of this chapter give valuable information on the general principles of natural and mechanical ventilation and the factors governing the choice between the two systems. The document carries the usual warning that, during the present abnormal conditions, it may not be possible to carry out all the recommendations.

Fundamental Economics in Hydro-Electric Design*

By C. M. ROBERTS, M.I.C.E.

In the hydraulic design of hydro-electric schemes it is first necessary to estimate the "long-term average rainfall" and, what is more important, the "long-term average run-off" for the catchment areas under consideration.

The extreme percentage deviations of the apparent from the true long-term average rainfall for various periods of observation were given by Sir Alexander Binnie† after detailed and careful analysis of a considerable number of rainfall records from various parts of the world. His conclusions are plotted in Fig. 1 for periods of observation up to thirty-five years, after which it will be seen that the extreme deviation is less than the error, estimated at 2 per cent, which is inherent in methods of rainfall-measurement.

In estimating long-term average rainfall, the greatest accuracy is therefore obtained if

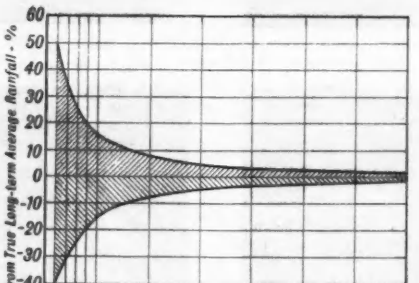


Fig. 1

rainfall records extending over a period of thirty to thirty-five years are available. In general, the statistical information which can be collected by the engineer is not sufficient to enable him to achieve this degree of accuracy, especially at present, when a solution to general power-shortages is being sought by major hydro-electric developments in remote and backward areas. When it is realised that the estimate of total power available is, as often as not, based on this estimate of long-term average rainfall, the importance of establishing rain gauges in areas where promising conditions exist for hydro-electric development may be seen.

Such records are rarely available and, in a great many cases, the long-term average run-off for a catchment area is derived from the long-term average rainfall figures for a number of points in the catchment, allowances being made for losses due to absorption, evaporation and so on, which vary with the type of catchment and which can sometimes be estimated with reasonable accuracy. Nevertheless, a check on the amount of these losses by direct measurement of river flow over a period of, say, ten years, is desirable; as will be indicated later, it is also a great advantage if the direct measurements of river flow are made either continuously or at comparatively short intervals of time—for instance, daily.

The direct method of plotting continuous or daily river-flow records, namely, the well-known flow-hydrograph, is of limited practical use in statistical analysis. By rearranging the information, however, it can be plotted non-dimensionally in a very useful form—the "flow duration" curve, an example of which is shown in Fig. 2—which indicates for what percentage of the total time the flow exceeds any given value. The great merit of this method of plotting river-flow records is that the curves obtained are often insensitive to variations within any particular type of catchment; that is to say, neighbouring catchments, or even catchments which are geographically far apart but which have similar topography and climate, often have flow/duration curves which are practically identical if plotted from run-off records covering a period of, say, ten years.

As mentioned above, the flow/duration curve for a catchment can often be assumed with a reasonable degree of accuracy if a reliable curve is available for another catchment having similar topographical and climatic conditions. By this means it is sometimes

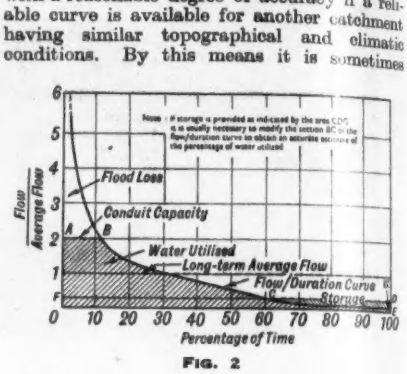


Fig. 2

possible to overcome an initial lack of river-flow records for the catchment under consideration and to predict, statistically, the nature of daily variations in run-off during a typical year.

If, instead of actual intensities of run-off, the summation of discharge is plotted, then the classical mass curve is obtained. As with the flow hydrograph, the mass curve is itself of little practical value in statistical analysis, and the method of plotting is inconvenient and laborious. From the mass curve, however, a most useful type of curve can be derived, which has great application when considering alternative developments of a catchment having a variety of storage possibilities.

Referring to the mass curve shown in Fig. 3, in order to find the amount of storage required to provide any particular regulated draw-off during the period for which the curve is plotted, lines representing draw-off are plotted from a point on the curve, chosen by inspection to give the worst condition. For constant rates of draw-off these lines are straight and the various amounts of storage required are given by the maximum ordinates AB, CD, and so on, which can be drawn between the lines and the mass curve. By plotting the values of storage against the corresponding rates of draw-off expressed as a percentage of the average run-off, that is to say, against the percentage of the run-off which is utilised, a "utilisation curve" is obtained. This curve (Fig. 6, curve (*a*)), when plotted from a mass curve covering a long period of years, including a very dry period, will show the amount of water and hence the power output, which can be guaranteed

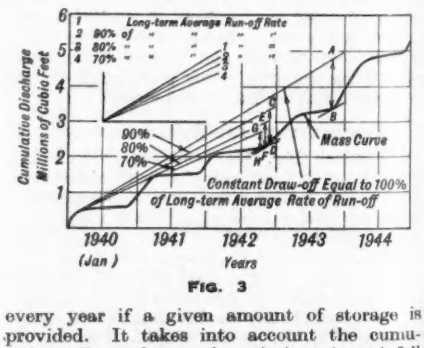


Fig. 3

every year if a given amount of storage is provided. It takes into account the cumulative effect of annual variations in rainfall and gives the "firm output" of the scheme.

Furthermore, this curve, when plotted non-dimensionally, tends to be insensitive to variations within similar types of catchment and a curve obtained from one catchment can often be applied to a neighbouring catchment with reasonable accuracy.

The main application of the flow/duration curve lies in calculating the most economical

*Institution of Civil Engineers, February 13th. Abstracts.

†"On Mean or Average Rainfall, and the Fluctuations to which it is Subject," Min. "Proc.", Institution of Civil Engineers, vol. CIX (1891–92, Pat. 3), page 89.

development of a catchment with little or no storage possibilities. In such a case it is usual to install a conduit having a capacity several times greater than the average flow. Since the area under the flow/duration curve in Fig. 2 is a measure of the total average run-off, then, if a conduit be installed, capable of handling, say, twice the average flow from the catchment, all the water represented by the hatched area (in this case about 72 per cent of the total run-off) can be utilised.

Fig. 4 shows the relationship between the conduit capacity, in terms of average flow, and the percentage of water which may be utilised. The value of installing a conduit and plant capable of handling more than the average flow is clearly indicated. On the other hand, an excessive increase in conduit size is required in order to obtain a very small improvement in the percentage of water utilised when working on the upper portions of the curve; for example, a conduit having a capacity equal to eight times the average run-off can use only 4½ per cent more water than a conduit of half that capacity. The most economical development lies somewhere in the middle portion of the curve.

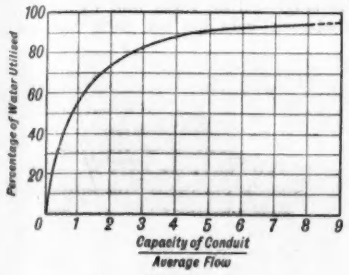


FIG. 4

Since the cost of differing sizes of conduit and appropriate plant installations and the value of total quantities of electrical units produced are known, a curve similar to that shown in Fig. 5 can be obtained. This shows the annual net profit of a scheme plotted against conduit size and refers to the catchment area, for which the flow/duration curve is given in Fig. 2. The flatness of this curve is of interest. A considerable range of annual outputs can be offered for which the amount of net annual profit obtained remains sensibly constant, although there is, of course, an increase in the capital investment corresponding to the increase in conduit-size.

Although run-of-river schemes do not require uneconomically large plant installations and conduits to achieve a high utilisation of the water available and can be operated in a grid system consisting of mixed steam and hydro-electric stations, schemes which have some storage usually prove more economical and useful if a reasonable location for the storage can be found.

The value of even a small amount of storage can be demonstrated very approximately by considering the flow/duration curve. If a horizontal line *FD* (Fig. 2) be drawn to represent, say, 30 per cent of the average flow, then the apparent storage necessary to regulate this is given by the area *CDG*. By virtue of the shape of the lower part of the flow/duration curve, this area and, therefore, the storage required to produce a firm output equivalent to 30 per cent of the average flow is comparatively small. If plant capacity just sufficient to absorb 30 per cent of the average flow be installed, the utilisation of this scheme would also be 30 per cent. In practice, however, more generating plant might be provided and the scheme considered as a modified run-of-river scheme with its flow/duration curve altered to take into account the effect of the small available storage. Thus, in Fig. 2, if plant capacity equivalent to twice the average flow be installed, all the water represented by the area *ABCDEO* may be utilised, but, by providing the small amount of storage, represented by the area *CDG*, the amount of water available for firm output may be increased from 6 per cent to about 30 per cent. This type of development nevertheless presumes that the unregulated part of the output can be accepted by the electrical supply system.

Referring to the utilisation curve shown in Fig. 6, curve (*a*), the value of ponding a small amount of storage is again indicated by the steep lower part of the curve, where a small difference in storage can give a considerable change in the guaranteed minimum utilisation of water. At the upper end of the curve the reverse is true: a considerable increase in storage can produce only a small change in the guaranteed minimum utilisation of water. For example, an increase of storage from 14 per cent to 21 per cent of an average year's run-off gives an increase in the utilisation of 14 per cent from 49 to 63 per cent. But a very large increase in storage from 55 per cent to 82 per cent of an average year's run-off only gives an increase in utilisation of 6 per cent from 84 to 90 per cent. A point is reached, therefore, when the provision of additional storage, normally at great expense, has little value in improving the firm output from a scheme; this effect is sometimes not fully appreciated. When a proposed grid system contains large amply reservoired schemes and a number of run-of-river schemes is being considered, it is sometimes particularly difficult to resist the demand for greater and greater storage at the large schemes in order to increase the firm output of the system as a whole, but this curve indicates how uneconomical this can be.

It has been shown how an increase in the storage-capacity from 55 per cent to 82 per cent, or one-and-a-half times, can give an improvement in firm output of only 6 per cent. The author considers that, for the same capital expenditure, a greater increase in firm output can be obtained either by partially regulating the run-of-river schemes or by providing storage at an entirely new development in another catchment, reverting in fact, in both cases, to the steeper and more fruitful part of the utilisation curve.

When considering how, for a given amount of storage, the utilisation of water can be increased above that indicated by the firm-output/utilisation curve, the nature of the load to be served becomes a factor of much greater importance than when dealing with firm output only. By increasing the amount of generating capacity installed, it is often possible to increase the output during wet years and thus obtain a higher practical utilisation. This assumes, however, that a grid-system can absorb the extra output by shutting down steam generating plant; or that the total output, which, during wet years, is normally greater than the firm output, can be reduced to the firm output during dry years without adversely affecting the consumer. A typical utilisation curve for a scheme operating in this way is shown in Fig. 6, curve (*b*). It gives the "long-term average output" for a given storage and assumes that sufficient generating plant is installed to enable the output to be increased, to some extent, during wet years. Unfortunately, it is not yet possible to predict weather sufficiently far ahead to enable storage to be operated at the maximum possible efficiency and the danger of over-running the scheme in the wetter seasons and being unable to produce the firm output during a subsequent dry spell always exists.

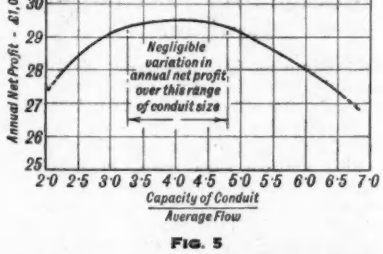


FIG. 5

Any ordinate, such as *AD* of Fig. 6, can be usefully divided into the three parts *AB*, *BC* and *CD*. *AB* represents the percentage of water available which is used in producing firm electrical units; *BC* represents the average percentage of water available which is used in producing so-called "spill" units; *CD* represents the percentage of water which is lost in flood discharge. The yearly electrical output of a hydro-electric scheme can then be defined as *X* firm units plus *Y* spill units. Spill units generally produce revenue at a lower rate than firm units because the output, as indicated by the long-term average utilisation curve, cannot be guaranteed. Spill units are, in fact, not available statistically except over a long period of years and cannot be produced at any given date. There are exceptions but, in many cases, this method of classifying the output can be of great use in considering the overall economics of a group of generating stations.

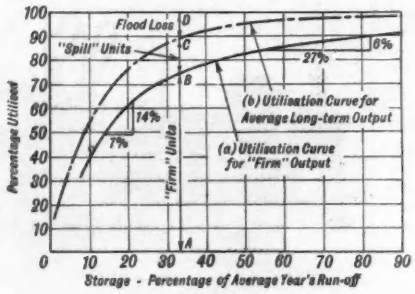


FIG. 6

It is not necessary to assume a constant draw-off when deriving a utilisation curve from a mass curve. In practice, however, it is found that the increase in percentage utilisation gained by taking into account seasonal variations in domestic load, for instance, is very small. Admittedly, the run-off often varies in the same manner as demand—high in winter and low in summer—but periods of high demand need only be slightly out of phase with periods of high run-off in order to lose much of the apparent advantage.

Further improvements in percentage utilisation of a scheme can only be made if the grid or supply system is capable of absorbing greatly increased output during comparative short wet periods. It is necessary to install a plant of considerably greater capacity than that required to absorb the average run-off in order to be able to utilise a larger amount of the flood-flows, which, after all, only obtain for a small percentage of the time as shown by the flow/duration curve. This extra plant, however, is often required to provide for the daily peak-output during periods of normal or low run-off and the arrangement can be quite economical. An example can be quoted in which the utilisation is estimated to rise from 88 per cent to 96 per cent by the judicious use of storage in the wet season, the plant being capable of absorbing two-and-a-half times the average run-off. This increase in utilisation is undoubtedly obtained more cheaply than by providing extra storage.

British Standards Institution

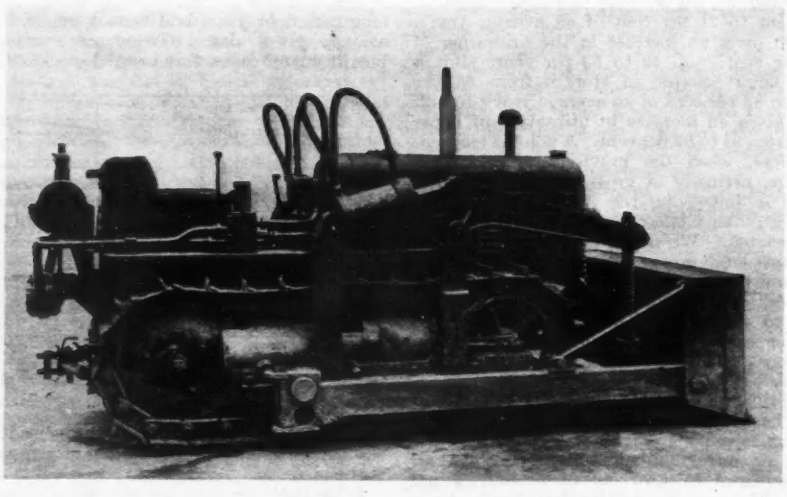
All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

SHIPS' COMPASSES AND BINNACLES

No. 1699 : 1950. This British Standard relates to the quality and performance of dry card and liquid compasses and binnacles for use in the navigation of merchant ships. It is identical with the specification given in the Appendix to the Ministry of Transport Notice No. M.345 and was prepared by a working party set up by the Ministry of Transport in 1946 to review the existing arrangements concerning ships and aids to navigation other than those of a radio nature. The Standard is divided into two parts. Part 1 deals with the compass and covers the directional system, card, azimuth-taking device, bowl, damping, induction error, securing of compass, requirements of accuracy and identification. Part 2 specifies for the binnacle the illumination, correcting devices, inclinometer sight, fixing and requirements of accuracy. Price 2s.

An Industrial Crawler Tractor

During the last two years or so, David Brown Tractors, Ltd., Meltham, Huddersfield, has added to its products a kerosene-engined "Trackmaster" crawler tractor, designed for agricultural work, both at home and overseas. The firm has now introduced another crawler tractor, which, while suitable for agricultural work calling for increased power, is intended mainly for other industrial uses, such as land reclamation and earth-shifting in connection with quarrying, opencast mining and similar operations.



Diesel Crawler Tractor with Bulldozer

The new tractor, which is known as the "Trackmaster Diesel," is fitted with a David Brown four-cylinder direct-injection diesel engine developing 31 b.h.p. at 1600 r.p.m. and 34 b.h.p. at a governed maximum speed of 1800 r.p.m. C.A.V. injection equipment acting directly into a toroidal-shaped combustion chamber, enables the tractor to be started up instantly by a heavy-duty 12V starter motor. Transmission is through a twin-range, three-speed gearbox, giving six forward and two reverse speeds, the final reduction being through spiral bevels and spur-gear drive. The forward speed range is from 1·06 m.p.h. to 5·72 m.p.h. at a rated engine speed of 1600 r.p.m., the reverse speeds being 1·27 and 2·62 m.p.h. The steering arrangement is on the maker's "Duotrack" principle, with geared epicyclic differential. It has been designed to give a positive drive under all conditions, power being transmitted constantly to both tracks. A claim made for the "Duotrack" system is that a controlled turn within a radius of 7ft to 8ft is possible. The standard track-shoes are 10in wide and the length of the tracks on the ground, from the centre drive sprocket to the centre of the front idler, is 5ft. The approximate ground pressure is 6 lb per square inch and, with 10in track-shoes, the area of ground contact is 8·35 square feet. The power take-off of the "Trackmaster Diesel" is integral with the rear axle and has four speeds, ranging from 468 to 1800 r.p.m. when the engine is running at 1600 r.p.m.

Hydraulic bulldozer equipment, as illustrated in the photograph reproduced herewith, has been designed for the "Trackmaster Diesel" by Blaw Knox, Ltd., Clifton House, Euston Road, London, N.W.1. The large-diameter hydraulic rams and crank arms are mounted on saddles over the tracks and are clear of abrasive materials which might cause excessive wear, and spring-loaded drop-arms have been incorporated to prevent shock loads being transmitted to the rams and piping. The hydraulic oil is supplied to the rams from a 4-gallon tank by a gear pump driven from the power take-off, which enables a positive oil supply to be maintained to the rams without overheating. The dozer blade is 5ft 8¼in long and 2ft 5½in high, and has a 6in tilt. Its maximum lift is 3ft 2½in and maximum dig 8½in. Blade control is by a three-position—lift, hold, lower—valve, and end-to-end blade tilt and the three-position angle of penetration are effected by convenient two-pin adjustments. The blade has closed ends, which not only give it some additional strength but also prevent side spillage.

At a recent demonstration near Huddersfield, the "Trackmaster Diesel," crawler fitted with the Blaw Knox equipment, was in operation under particularly sticky conditions. The demonstration included some effective site-levelling and side-hill excavation, and trench-dozing with two machines working in unison. David Brown Tractors, Ltd., also showed in operation at the same event the prototype of a 45 h.p. "Trackmaster" tractor equipped with a Blaw Knox ¾ cubic yard scraper.

Storage Bin Discharging Equipment

An equipment for discharging all types of powdered materials from bulk storage bins at a steady controlled rate has been introduced by the Bulkbin Company, of Cainscross, Glos. This equipment has been developed for use with vertical sided bins, in which any tendency a material has to "bridge" or "avalanche" during extraction is avoided.

The discharging equipment consists essentially of a specially designed conveyor unit, which sweeps across the surface of a raised false floor in the bin. The material rests on this false floor, which is inclined towards the rear and is slotted across its full width at regular intervals. The conveyor is built up of cross-bars mounted between chains running along each side of the false floor. As they are drawn by the chains along the floor the bars shear off the lowermost layer of the stored material and sweep it into the slots. As the material drops through the slots down on to the main floor of the bin it is picked up by the bars on the return run of the conveyor and swept forwards in a steady stream to fall into a boot at the front of the bin.

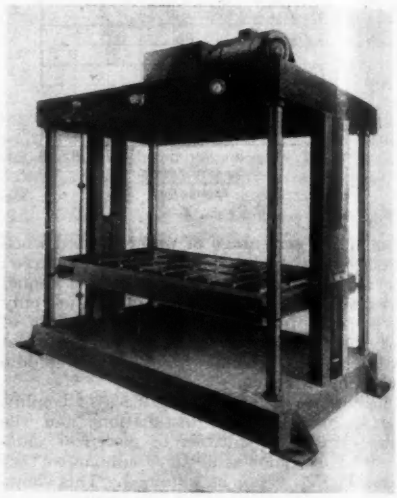
The conveyor chains are driven by a small motor through a reduction gear and a secondary shaft at the rear of the bin. The drive mechanism incorporates crank-driven claws and is so arranged that each chain is pulled alternately through a short distance. In this way as each of the bars moves along the false floor of the bin, it imparts an end-to-end or sideways slicing effect on the material. As the full power of the drive is applied to one chain at a time it has been possible with this design to use a smaller motor than would have been necessary had the conveyor been driven as a complete, continuous unit.

The conveyor chains are built up from interchangeable laminated plate links and can be built up in various combinations to suit different materials.

Hydraulic Baling Machine

A 20-ton hydraulic baling machine, now being made by Chamberlain Industries, Ltd., Staffa Road, London, E.10, is illustrated below. This machine is designed for a wide range of work, and its 4ft 6in by 2ft 9in table has a working stroke of 4ft 10in. It is rigidly built up of fabricated steel plates and sections and is designed for floor mounting without necessity for a pit.

The table is operated by two hydraulic upstroke single-acting rams and cylinder units, set between columns on each side of the machine. A chain multiplication mechanism is used to increase the ram stroke movement from 20in to 40in. When at the end of a working stroke the hydraulic cylinder release valve is opened, the weight of the table and its load are sufficient to discharge the oil and return the table to its lowermost position.



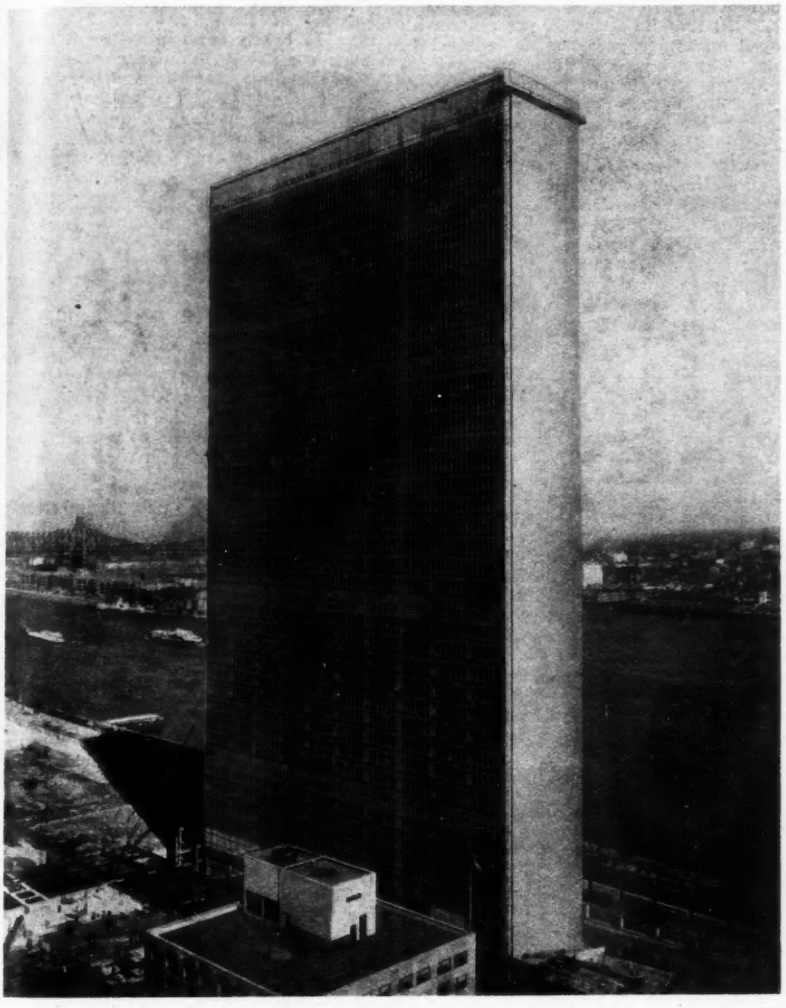
20-Ton Baling Machine

Power to operate the rams on the upward stroke is supplied by a high and low-pressure swashplate pump, driven by a 2 h.p. electric motor. At low pressure a rapid approach to the work is obtained, the change-over to high pressure for working being automatic. Where only a light pressure is required it can be obtained by setting the variable relief valve; working pressure is indicated on a gauge mounted at the front of the machine. At the end of each full stroke during normal high-pressure working the control lever is automatically returned to the neutral position to eliminate any possibility of over-travel by the table.

Film About Concrete.—We were recently invited to a performance of the film, "Concrete," which has been made by John Laing and Son, Ltd. The film is in colour and runs for about thirty minutes; it illustrates the many uses of concrete in the present-day sphere of public works and constructional engineering, and as an example of modern practice depicts the building of an airport runway. The batching of the concrete is shown and described, with explanations of the function of a site laboratory for testing. A twin-batch "paver" is then shown in operation and its action described, followed by descriptive scenes of mechanical spreaders and finishers. The film is the third which the company has made and like its predecessors, "Moving Earth" and "Building Homes," may be borrowed, free of charge, on application to the Public Relations Department, John Laing and Son, Ltd., Building and Civil Engineering Contractors, London, N.W.7.

The United Nations Secretariat Building

FROM the time the United Nations Organisation was established in San Francisco in 1945, its need for a permanent home has been evident. After spending the last five years in temporary quarters—from Church House, Westminster, to Lake Success, Long Island—the administrative section of UNO is, at present, moving into the Secretariat Building, the first unit of the permanent headquarters in New York City to have been completed. It will be recalled that the decision to maintain UNO headquarters in the United States followed an invitation from the U.S. Congress at the end of 1945. During 1946, UNO committees inspected various sites which were offered throughout the country, particular consideration being given to those in Philadelphia, Boston, San Francisco, and the metropolitan area of New York. While the second part of the first regular session of the General Assembly was in session in New York in 1946, an offer of 8,500,000 dollars for the purchase of a site along the East River boundary of Manhattan, extending from 42nd Street to 48th Street, was made by John D. Rockefeller, jun., and accepted by the United Nations. The gift was contingent upon the willingness of New York City to contribute the street areas, riverfront rights, and other portions of land that would make the site continuous and uninterrupted—a condition which the city was prompt to meet. Throughout 1947 the Headquarters Planning Commission, composed of a group of architects from many nations, worked on site development plans, and the U.S. Government extended a 65,000,000-dollar interest-free loan agreement to finance the project. The buildings of the Headquarters consist of four main units: the 39-storey Secretariat Building, the General Assembly Building, the Meeting Halls area, and, at a later stage of construction, a building to accommodate delegations and specialised agencies, to be erected at the north end of the 17-acre site. At the same time, technical studies were conducted by a number of consulting engineers, and eventually engineering designs were prepared. The site was cleared during 1948; architectural and engineering details were settled, and excavation was begun in September, 1948, and completed in five months. Erection of the 12,500 tons of structural steelwork commenced in April, 1949, and was completed in October of that year.



THE UNITED NATIONS SECRETARIAT BUILDING

Foundations

Cores recovered in an initial set of drillings showed the rock at the site to be typical Manhattan schist, generally dipping at an angle of 60 deg. with the horizontal. Except for some soft areas, the rock was found to be generally sound and capable of supporting the loads allowed by the New York Building Code. At the site of the Secretariat Building the rock surface slopes down towards the East River, which meant that, in order that the entire building structure should be supported on solid rock, it was necessary to carry a number of the eastern columns to bedrock by open pier excavation. The basement for the Secretariat required rock excavation over most of its area to obtain the desired depth. Decomposed rock was found at certain locations and made it necessary to drill to depths of as much as 30ft from the rock surface in order to establish sound, hard rock. Extremely heavy wing plates, up to 5in in thickness, are riveted to the bases of the bottom columns to distribute the building load to the 11ft by 4ft grillages resting on the concrete piers. Altogether, 150,000 cubic yards of earth and 65,000 cubic yards of rock were removed by the contractors.

Structural Frame

The Secretariat Building is a tower structure, 287ft long, approximately 72ft wide and 500ft high above the entrance level. The building has thirty-nine storeys, three basement levels and a penthouse. It has a striking appearance, as may be seen from the accompanying illustration: an unbroken opaque stretch of white Vermont marble on its north and south faces—an almost transparent expanse of glass on the east and west walls, which are covered with long horizontal bands—bands of faintly tinted, glareless windows, bands of black glass to conceal the floors and ceilings, and bands of metal grillwork at three windowless mechanical floors, which contain air conditioning equipment, electrical and signalling devices, blowers and fans. There are eleven column lines spaced 28ft apart along the building and four lines of columns across the building. The two interior lines of columns are 18ft 2in apart and are displaced 3ft 6in from a symmetrical location. The framing is structural steel throughout with beams arranged to support short-span reinforced concrete slabs. The preliminary design had been based on the general requirements of the New York City Building Code and on the use of standard structural steel. The New York Code requires a live load of 50 lb per square foot for the upper floors of office buildings and further requires that an additional allowance of 20 lb per square foot be assumed to provide for subdividing partitions. The ground floor, basement floors and any spaces allocated to public use or assembly are required to be designed for a live load of 100 lb per square foot. The Code specifies a basic maximum unit stress of 18,000 lb per square inch for structural steel. The adoption of a spacing of 28ft between column lines was governed by the arrangement of lifts and by a desire to keep the number of interior columns to a minimum. The best arrangement of columns across the building from a purely structural standpoint would have been a symmetrical arrangement of four columns with a distance of about 21ft 2in between the interior columns. However, for the best utilisation of space and to match the lift lay-out an unsymmetrical arrangement was adopted. The additional weight thus required amounted to about 3 per cent of the total tonnage.

The New York City Building Code requires a wind loading of 20 lb per square foot applied to the surface of the building above a plane 100ft above the ground. The American Standard Building Code specifies a wind loading for structures in the New York City region varying from 20 lb per square foot at the base to 34 lb per square foot at the top, for a building of the height of the Secretariat Building. Based on experience with tall structures in this region, a wind loading for the Secretariat Building was used amounting to 20 lb per square foot at the 100ft level and gradually increasing to 30 lb per square foot at the top, with no wind pressure applied to the surface below the 100ft level. Because of the slenderness of the structure wind forces are relatively high in the lower floors, and 1¼in rivets were specified for the east-west wind girder connections up to the seventeenth floor. Generally, the wind girders are connected to the flanges of the columns with T-shaped beam stubs at top and bottom. To resist the negative moment the girders are reinforced at both ends with cover plates extending to the quarter points of the span. Experience with tall building frames has shown that unless the theoretical deflection of the steel frame is kept less than one-five-hundredth of the height of the building there will be too much

movement of the building in storms and cracking of walls and partitions will result. To obtain sufficient rigidity the size of main wind girders was determined by the stiffness required rather than the strength to resist wind loads, so that heavy connections were used in joining the wind girders to the columns.

The floor construction is a short-span concrete slab reinforced with welded wire mesh. The floor beams span the 28ft between columns or wind girders and support the floor slabs at 9ft or 10ft intervals. Stone concrete is used for the ground floor and floors below ground, and the slabs for floors above the ground floor have lightweight aggregate resulting in a concrete with a weight of about 108 lb per cubic foot. The structural slabs for the office floors are 4in to 5½in thick and were designed for a live load of 50 lb per square foot plus a partition load of 20 lb per square foot.

Heating and Ventilation

The Secretariat is completely air conditioned. The exterior portions of each floor—up to 12ft from the windows—are served by a high-velocity system, with units situated under six of the seven windows in each bay, with alternate units containing temperature controls. Each individual network of under-floor air conditioning conduits is connected to one of four major risers, which furnish the conditioned air from central apparatus situated at the sixth, sixteenth, twenty-eighth and thirty-ninth-floor levels. The individual office air conditioning units are mounted against the insulated spandrel wall and just below the window. The employment of a circular conduit design instead of the conventional rectangular duct sections has saved considerable space and made possible a floor-to-floor height of 12ft with a floor-to-ceiling clear height of 9ft 6in. The air conditioning ducts pierce the floor beams and then turn upward through sleeves in the cement floor to connect with the office units. The remainder of the floor is served by a conventional low-velocity system with inlet diffusers and exhaust outlets contained in the suspended acoustical ceiling. The outlets adjoin recessed fluorescent lighting fittings, which are 4ft long and are spaced at 7ft pitch, centre to centre, in order to provide the required intensity of 30 foot-candles at desk level. The 1½ft space between the ceiling and floor slab above serves as a return plenum for exhaust air. Additional heat is provided by radiant heating wrought iron coils in the floor of the first floor lobby, where 1in pipe is used, and on the inside faces of the north and south facades, where ½in pipe is installed.

Lifts

The building is provided with eighteen high-speed passenger lifts, two service lifts, a freight lift and eight escalators. Six of the passenger lifts terminate at the fifteenth floor, six at the twenty-seventh floor, and six at the thirty-ninth floor. Two of the last bank are night lifts, which serve the three basements as well as all floors above ground. The high-speed lifts have a speed of 1200ft per minute, the medium ones 1000ft per minute, and the low ones 800ft per minute. The service lifts serve the basements and all thirty-nine floors. The freight lift is of the hydraulic plunger type and operates at 50ft per minute. It serves the second and third basement floors, where mechanical facilities are housed. The escalators extend from the first basement lobby, which leads to an indoor parking garage to the fourth floor. Both lifts and escalators are centrally situated in the building and do not disrupt the continuity of the glass exterior. For such purposes as inter-office mail distribution the Secretariat has an electric "dumbwaiter" system and a vertical conveyor system extending from the third basement to the thirty-ninth floor. In addition, there is a pneumatic tube system with a central station in the third basement and tube connections to stations on the tenth and fifteenth floors, the library and the Meeting Halls building, which is now in the course of construction.

Edwards and Hjorth were structural consultants, Syska and Hennessy mechanical consultants, and Moran, Proctor, Freeman and Mueser foundation consultants in the design of the Secretariat. The general building contract, valued at 23,809,573 dollars, was held by Fuller-Turner-Walsh-Slattery, Inc., and the steelwork was erected by the American Bridge Company.

Continental Engineering News

Bridge Reconstruction in Hungary

During the second World War Hungary sustained destruction of many bridges. Their total length amounted to some 90,000ft. Amongst other structures all bridges over the Danube and the Tisza were destroyed. The damage involved mainly long-span bridges (over 165ft). During the three-year industrial plan put into operation soon after the end of the hostilities, 1378 bridges, totalling a length of 83,000ft, that is, about 91 per cent of all damaged structures, were either repaired or rebuilt. The five-year plan for the development and modernisation of Hungarian industry and agriculture (1950–54) contains an important provision for the reconstruction of bridges. During the first year of the plan about 100 bridges were restored, the most important being the Stalin Bridge, over the Danube, recently opened in Budapest. Another notable bridge was completed in 1950, over the Tisza, near Polgar. Owing to its construction, the distance between Miskolcz and Debreczen (N.E. Hungary) was reduced by 25 miles. An aluminium bridge, now nearing completion, will be the first light metal bridge in the country.

Golden Jubilee of Swiss Constructional Firms

Two important Swiss constructional firms celebrated recently the fiftieth anniversary of their foundation. They are Conrad Zschokke, of Döttingen, and Eisenbaugesellschaft (E.B.G.), of Zurich, both of which are concerned with structural steelwork. During the past half-century they have erected many important structures. Amongst the more interesting achievements of the E.B.G. Company are the Limmat bridge in the Canton of Zurich, the department store Jelmoli and the Oerlikon Stadium, at Zurich, and the building of the newspaper, Neue Zurcher Zeitung. The Conrad Zschokke Company, for its part, was responsible, for example, for the Kloten and Cointrin aircraft long-span hangars.

A Large Cement Factory in Belgium

In January, 1951, Monsieur Coppé Belgian Minister of Economic Affairs, opened Europe's biggest and most modern cement factory. This plant, belonging to the Cimenteries and Briqueteries Réunies, is situated at Lixhe, on the Albert Canal, 20 miles north of Liége. Its construction necessitated the investment of some 600 million Belgian francs (£4·3 million), which were put up by Belgian banks and insurance companies. Dollars needed for the purchase of the American equipment of the plant were provided by the E.C.A. The Lixhe plant, which has an annual production capacity of some 400,000 tons, was built in eight months. The plant is equipped with two 500ft-long ovens, operated entirely from a central switchboard that controls everything from the temperature of the burning gases and the speed of production to the cooling of the clinkers. The shipment of finished cement will mainly be done at the private port on the Albert Canal, where 600 yards of quays have been built.

Six-Year Plan for the Reconstruction of Warsaw

In addition to the six-year plan for industrial development now in operation in Poland, a plan extending over the years 1950–55 has been prepared for the reconstruction of Warsaw. According to the scheme, housing accommodation will be increased by 120,000 dwelling-rooms during that period. New hospitals, theatres, cinemas, as well as 218 schools, will be built. By the end of 1955 the Polish capital will have 550 tramcars, 150 trolley-buses and 300 buses and the carriageways of many streets will be modernised. It is proposed to start works on the construction of an underground railway, while the electrification of the suburbs will be completed. The plan also contains provision for preliminary works dealing with the construction of the Zeran port on the Vistula River. Many famous buildings, such as the ancient Royal Palace, the Grand Theatre, &c., will be restored.

The North-South Junction Railway, Brussels

According to a report presented in January to the members of Belgian Parliament, the present state of the great engineering works destined to link the North and South stations of Brussels, about 2 miles apart, may be briefly summarised as follows. The work completed includes about 2130 yards of the tunnel; the terminal buildings of the Central Station and of the Chapelle Station; the South viaduct and a number of bridges. Work partly completed includes tracks on filled ground between retaining walls, a subway for tramways and four ventilation towers near the Central Station. Both terminal buildings for the new North and South stations are completed. At the South Station seventeen tracks (out of twenty-two) are already rebuilt at a level some 20ft above the existing track level; at the North Station five tracks (out of seven) are in service. The work in progress includes the central ventilation building for the railway tunnel and the associated mechanical and electrical equipment, and the raising of two more tracks at the North Station. It is expected that in the first quarter of 1953 six tracks will be opened to traffic between the North and South stations.

SKF Roller Bearings of Record Dimensions in Sweden

The two largest self-aligning roller bearings ever manufactured by SKF were recently delivered by their Gothenburg works to France. They are to be used in a sluice-gate and each weighs 5000 lb. Their dimensions are: internal diameter 33½in; external diameter 53½in and width about 16in. The materials for the outer ring were forged at the Hofors iron foundry, which belongs to SKF. The subsequent stages of manufacture were carried out at the Gothenburg works.

Electricity in Switzerland

The annual report of the "Association Suisse pour l'Aménagement des Eaux" contains interesting data on the development of electric energy in Switzerland.

During 1949 eight power stations were completed, with an aggregate capacity of 117,400kW and an annual output of about 605 million kWh. By the end of 1949 the total capacity of Swiss hydro-electric plants amounted to 2,739,000kW. During the period 1948–49, Swiss power stations produced 9,880,000,000kWh, almost entirely supplied by hydro-electric plants.

In the course of 1950 twenty-seven power stations were either under construction or undergoing important extensions. Of these, twelve plants will be completed in 1950, the completion of the fifteen others being contemplated between 1951 and 1954, except the Grande Dixence plant, which will not be wholly in service until 1958. The consumption of electric energy by industrial users (including railways) and domestic users amounted in 1948–49 to some 9½ million kWh. It is hoped that when the Swiss electric energy supply scheme is completed in 1954 the capacity of Swiss hydro-electric and thermal power stations (totalling some 14,763 million kWh) will be sufficient to meet all needs of the country, irrespective of weather conditions.

Portable Pipe-Sawing and Thread-Milling Machine

SHORTLY before the end of last year an interesting machine for cutting and threading gas and water pipes was demonstrated at the works of the Ruhrstahl A.G. Presswerke, of Brackwade, Westphalia. It is said to be finding a wide use on many of the house and factory-building and repair schemes which are now being pressed forward in Western Germany. As shown by our illustrations, the machine can be mounted for hand transport or on a framework suitable for a trailer behind a car or van. The model we illustrate is the R.G.2 pattern, which has been designed to deal with pipes from ½in up to 2in in diameter. The machine is driven by a 550W electric motor arranged for coupling to 220–230V a.c. lighting or power circuits. If desired, a small petrol engine can be fitted. The motor drives a saw and a milling hob through a worm drive and a vee belt. The pipe to be cut and threaded is gripped in a three-jaw self-centring chuck. At each end of the machine there are supports which can be swung out to steady the ends of a long tube.

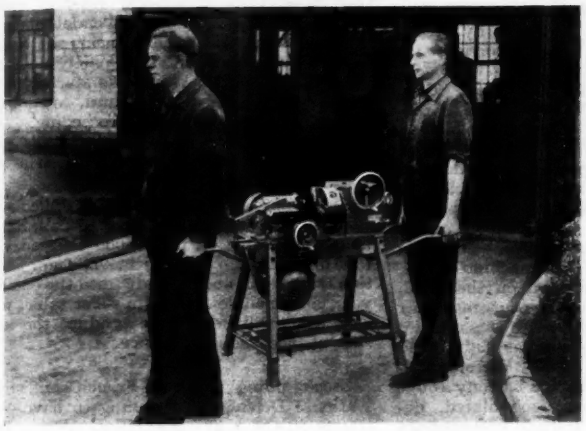
The saw spindle is mounted on a slide. In operation the saw is advanced towards the pipe until it penetrates the wall thickness. The pipe is then rotated by turning the handwheel, which operates the chuck; thus any desired length of tube can be cut off.

For the thread milling operation the axis of the hob is slightly inclined to the pipe axis so that a coned or tapered thread is formed. The cutting depth is preset for any chosen pipe diameter by a stepped rotatable collar immediately behind the slide handwheel. The movement of a lever below the workhead handwheel engages a drive and causes the chuck to rotate at a speed properly related to that of the milling cutter.

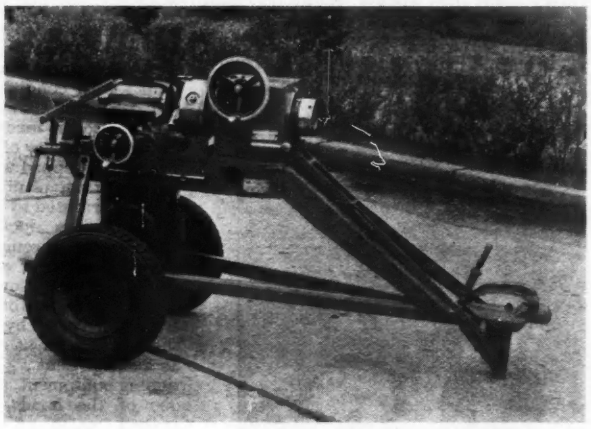
During the sawing and thread milling operations only one hand is needed to operate the machine and the work can be therefore lubricated by an oil-filled brush held in the other hand. A pocket is provided just below the chuck for the reception of the brush.

The time taken to saw and thread a 2in pipe is about 3½ minutes and it is claimed that the machine effects a saving of something like 75 per cent in time compared with that needed for cutting and screwing a pipe by hand.

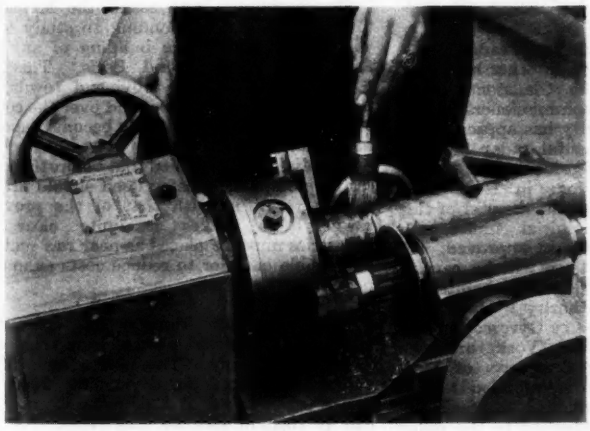
The firm of J. C. Neville, Ltd., of 27, Martin Lane, Cannon Street, London, E.C.4, has been appointed the British agent of the makers. We are informed that a trailer model is now in this country and is ready for demonstration to interested users by Mr. Arthur T. Scales, of 58, Copthall Gardens, Twickenham, Middlesex.



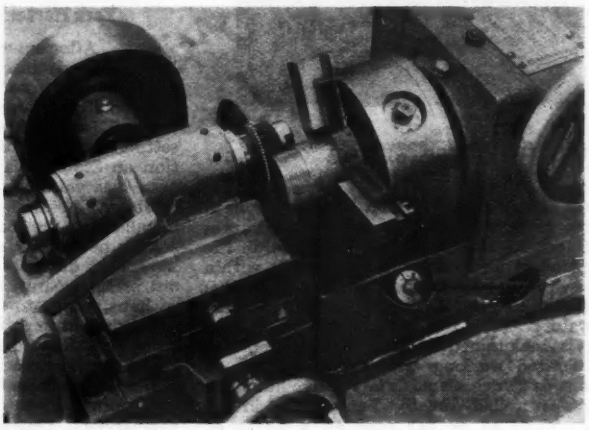
MACHINE MOUNTED FOR HAND TRANSPORT



TRAILER MACHINE



PIPE-SAWING



THREAD-MILLING

Technical Reports

The Investigation of Road Foundation Failures. Road Research Technical Paper No. 21. H.M. Stationery Office, price 1s. 6d.—This report outlines the various types of failure produced in road surfacings by defects in the road foundation and describes the methods developed by the Road Research Laboratory of studying these failures on the site. Road engineers should find this paper of assistance to them in establishing the cause of the structural failure of any road in their area: such information is of vital importance in ensuring that the method adopted for reconstructing the road is both effective and economical.

The Measurement of the Time Constant of a Critically Damped Meter (Ref. M/T107). By S. F. Pearce, B.Sc., A.Inst.P. The British Electrical and Allied Industries Research Association. Price 3s., postage 3d.—Specifications of the performance characteristics of receivers for the measurement of radio interference prescribe that the final indicating meter be critically damped and that its time constant be within specified limits. This report analyses the response of such a meter to a uni-directional square wave of current having a one-to-one mark-to-space ratio and suggests a simple method for determining the time constant.

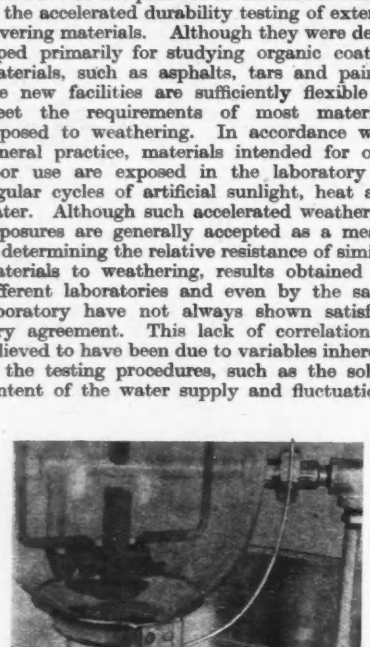
An Experimental Synchronous Contactor for Repeated Automatic Operation (Ref. G/T241). By H. W. Baxter, B.Sc.(Eng.), A.M.I.E.E. The British Electrical and Allied Industries Research Association. Price 3s. 3d., post free.—This report describes the design and operation of a small contactor, constructed to facilitate the experimental investigation of contact wear, and permitting the independent control of contact pressure, velocity of contact separation, the point on wave at which contacts separate, and the relative sliding between contacts. The fact that these variables can be controlled separately places the experimental contactor at an advantage compared with commercial contactors, when used for experimental work.

American Engineering News

(From our American Correspondent)

Durability Testing of Protective Coatings

A laboratory which was recently designed and constructed by the Building Technology division of the National Bureau of Standards, eliminates the major difficulties that have in the past led to anomalous results in the accelerated durability testing of exterior covering materials. Although they were developed primarily for studying organic coating materials, such as asphalts, tars and paints, the new facilities are sufficiently flexible to meet the requirements of most materials exposed to weathering. In accordance with general practice, materials intended for outdoor use are exposed in the laboratory to regular cycles of artificial sunlight, heat and water. Although such accelerated weathering exposures are generally accepted as a means of determining the relative resistance of similar materials to weathering, results obtained by different laboratories and even by the same laboratory have not always shown satisfactory agreement. This lack of correlation is believed to have been due to variables inherent in the testing procedures, such as the solids content of the water supply and fluctuations



ACCELERATED EXPOSURE TESTING OF COATING SAMPLES

in the light intensity, which have so far been largely uncontrolled. It is expected that automatic control of all these functions and of the temperature and purity of the water within narrow limits will ensure uniform operation at all times of the new accelerated weathering laboratory. The test room, 16ft by 25ft in size, is maintained within ±1 deg. Cent. of any desired working temperature, which, at present, is 27 deg. Cent. The relative humidity is not controlled directly, but remains in the range of 40 to 60 per cent as a result of the sub-cooling of the fresh air brought into the room. The floor area is divided into three portions: a central working space and two areas containing the testing machines.

Within one hood there are six testing machines, which were built at the Bureau to utilise the enclosed carbon-arc as a source of light. A number of sample coatings mounted in position within the drum of one of these machines are shown in the accompanying illustration. The operating range of each light may be controlled within 130V to 145V and 15A to 17A by means of ballast resistances put in series with the arc. The aluminium drum is 31in in diameter and is able to hold sixty exposure panels. It is rotated around the arc-light at the rate of 1 r.p.m. Air at ambient conditions is circulated in the vicinity of the exposure panels at a low velocity until they reach a predetermined maximum temperature. Then a thermo-sensitive element, mounted in one of the panels, turns on a high-speed blower, which increases the air flow materially and thus reduces the panel temperatures. Deionised water, controlled by a cycle timer, can be sprayed on the test panels during any part of their exposure period. The heart of each machine is a time-delay relay, which turns off all functions of the machine if the arc should cease to operate for a period in excess of thirty seconds. Voltage and current values are indicated continuously, while the running time and power consumed by the arc are recorded by instruments on each machine. An air-conditioning unit of considerable size would be required to control the temperature of the space surrounding the testing machines, which dissipate a total of 39kVA of energy. The temperature is, therefore, regulated by blending various amounts of outside corridor air (at temperatures ranging from 15 deg. to 35 deg. Cent.) with conditioned air at 25 deg. Cent., ±1 deg. Cent. The resultant mixture is distributed to the machines by means of a blower, having a capacity of 2000 cubic feet per minute, which is equipped with a proportioning damper in its intake plenum. In turn, the blended air is distributed to the vicinity of each machine by aluminium ductwork. Conditioned air is also drawn through a 2in opening running along the floor of each of the machine hoods, by an exhaust blower mounted on the hood, which removes about 30 per cent more air than is delivered by the ducts. In this manner the ambient air at each machine is maintained at 29 deg. Cent., ±4 deg. Cent. Water-conditioning equipment, situated on a balcony above one of the hoods, delivers recirculated, deionised water at any desired temperature between 4 deg. and 25 deg. Cent. (±1 deg. Cent.) to the machines. At present, to introduce a cyclic thermal shock to asphalt exposure panels, the equipment is operated at 5 deg. Cent. and a pressure of 25 lb per square inch. The pH value of the water is maintained by the de-ionising apparatus at 6·2. Water for the other machines is delivered at room temperature and at a pH value of 6·0. All the machines can be operated with tap-water if de-ionised water is not required.

Experimental Radar Installation for New York Harbour

After extensive studies of radar installations already in operation in other harbours, including the one at the Gladstone Dock, Liverpool, the board of commissioners of the Port of New York Authority has approved the setting-up of an experimental radar installation on Staten Island, to guide vessels during poor navigational conditions in New York Harbour. Estimates show that the cost of this installation during the initial nine-month testing period, which has been approved, will be 45,000 dollars. The tests will be carried out using apparatus provided and maintained without charge to the authority by two leading manufacturers, the Sperry Gyroscope Company, of Great Neck, New York, and the Raytheon Manufacturing Company, of Waltham, Massachusetts. It is intended to use two competitive installations, to facilitate comparison. Operators attached to the radar station will maintain contact during the tests with men who will be assigned to freighters and liners moving in and out of harbour waters. For this purpose the Port Authority will provide radio-telephone equipment. Furthermore, pilots from Sandy Hook and others co-operating in the experiments will carry "walkie-talkie" sets to maintain constant touch with the shore radar station. Foggy weather in New York Harbour occurs about 5 per cent of the time.

French Engineering News

(From our French Correspondent)

Work at the port of Conakry in French West Africa includes the construction of a new 300m quay for handling minerals, a 150m quay for handling fruit, and an 80m quay for small coasting ships.

When the work is completed Conakry will be able to take 25,000-ton vessels drawing 10½m, and the port will be able to handle some 1800 tons of merchandise per hour. It is hoped that later on the capacity will be increased to 3000 tons by the installation of new handling material.

Work is also to be undertaken on the railway running from the mineral mines to the port. At the moment there are two narrow-gauge lines, but a third 1m gauge line is to be added. This new line will enable the use of standard type 65-ton trucks.

* * *

A financial arrangement which has united the Société Les Petits Fils de François de Wendel with the Société de Wendel has given the latter firm a mineral reserve covering 10·125 hectares. The de Wendel plant was taken over by the Germans during the war and, when the Germans left, they partly dismantled some of the mills. Work was started in 1948 on a vast modernisation and re-equipment programme and is still proceeding. Some forty-four furnaces have been rebuilt and a new electric generating station has been installed.

* * *

Additional equipment being installed at the Longwy steel works at Mont St. Martin will increase production from 6000 tons to 15,000 tons of steel plate per month. The new installation, which will not be ready until the end of the year, also include a new 4m roller table, which, it is said, will be able to produce the largest sizes of sheet metal in France.

* * *

Stock piling by the French Ministry of National Defence is beginning to have serious effects on the heavy industries. Aluminium is said to be scarce, and copper is severely controlled.

There is a general feeling in France that there will be a general shortage of raw materials for the heavy industries varying from 25 to 50 per cent according to the metal and its uses.

The shipbuilding industry is expected to be badly hit by the new restrictions and ship repairs are already being held up. Steps are being taken to introduce a system of steel priorities to ascertain that the most important work is carried out first.

* * *

The provinces have asked the Minister of Town and Country Planning to study a plan which will prevent the building of any more factories in and around Paris. This plan, drawn up by several provincial towns, asks that industry should be spread over the country and that the provinces should become important industrial centres.

The Minister has replied that before the scheme can be accepted industry itself should draw up a plan to fit in with that of the provincial towns. He makes it quite clear that industries must be placed as near raw materials as possible in order to reduce costs as much as possible.

* * *

The French Air Ministry has ordered 160 twin-engine freight planes from the Louis Breguet Company. The planes have Bristol "Hercules" engines, developing 2040 h.p., and a mean speed of 335km per hour. They can fly 1500km with a 5 tons cargo.

* * *

The following electricity production figures have been published. During the first six months of 1950 consumption was only 5 per cent above the corresponding period in 1949 and below the consumption of 1948. The last six months of the year, however, showed an increase up to 11 per cent above 1948, which is double the consumption in 1938. Total power production in France is now about 85 million kWh per day.

Industrial and Labour Notes

British Overseas Trade

Provisional figures relating to Britain's overseas trade in January were published at the end of last week by the Board of Trade. Exports of United Kingdom goods during the month were valued at £214,400,000, which was £33,500,000 above the monthly average for last year. There were twenty-seven working days in January and the daily rate of export was 2·6 per cent below the peak figure attained last November, but was about the same as the rate for the fourth quarter of 1950.

January exports from this country to the U.S.A. were valued at £11,000,000, which was £1,800,000 less than the average for the fourth quarter of 1950, but £1,500,000 above the monthly average for the whole of last year. Exports to Canada in January were valued at £9,500,000, a decrease of £2,800,000 compared with the monthly average for the fourth quarter of 1950, and £1,000,000 less than the average for the year as a whole.

Imports into the United Kingdom, valued provisionally at £298,400,000, showed a big increase, as they exceeded the 1950 monthly average by £81,500,000. Re-exports in January have been valued at £8,600,000, so that the excess of imports (valued c.i.f.) over total exports (valued f.o.b.) was £75,400,000, against a monthly average for last year of £29,000,000.

The Coal Situation

Lord Hyndley, Chairman of the National Coal Board, made a speech in London last week, reviewing the past performance of the Board and commenting on the coal-mining outlook for the current year. He quoted output figures for the years 1946 to 1950, pointing out that in that period the annual deep-mined production had increased from 181,000,000 tons to 204,000,000 tons. That, Lord Hyndley said, was not as good as had been hoped, and last year, in particular, had been disappointing mainly because of the heavy fall in manpower. Nevertheless, he claimed that the increased output was a solid achievement by the men of the industry, as output per man per year had risen from 260 tons in 1946 to 293 tons last year.

Dealing with manpower, Lord Hyndley said that last November the number of wage-earners on colliery books had fallen to 686,400. In the week ended February 10th the figure was 696,500, an increase of 10,000 in three months. He agreed that recruiting was always better at this time of year, but this year's increase was much greater than in the two preceding years. It was not known, however, how long the improved trend would continue. Against the manpower background, Lord Hyndley went on to say, it was very difficult to make any sound estimate of output this year. It could not be assumed that the number of men in the industry over the whole year would be even as high as in 1950, and coal production might not be as much as it was last year. But he thought that the recent wage agreement and the discussions on a pension scheme should make for stability in the industry.

Lord Hyndley commented also on inland prices of coal, saying that the latest increase of 4s. 2d. a ton was intended to cover the two recent wage increases, the greatly risen costs of stores and materials and the loss on imported coal, and to offset the loss of revenue on account of reduced exports. That increase, being flat-rate, was not consistent with a reformed price structure towards which the Board was progressively moving, and adjustments upwards and downwards would be made in the next instalment of the price structure. The additional revenue was unlikely to enable the Board to do more than make ends meet in 1951.

The latest figures issued by the Ministry of Fuel and Power show that last week production of deep-mined coal was 4,343,500 tons, and of opencast 167,700 tons, making a total of 4,511,200 tons. In the week ended February 10th, inland coal consumption was, at 4,518,000 tons, slightly lower than in preceding weeks. Exports and bunkers took 170,000 tons, so that total consumption amounted to 4,688,000 tons. Distributed stocks at the end of the same week totalled 9,967,000 tons. The Ministry says that less coal was withdrawn from stocks between February 3rd and 10th than in any week since the beginning of November, the actual amount being 146,000 tons.

Labour and the Armament Programme

During the debate on defence in the House of Commons on Thursday of last week, the Minister of Labour, Mr. Bevan, said that he had discussed with trade unions' and employers' representatives the subject of mobility of labour. The conclusion had been reached that it would be premature to reach a decision about the direction of labour—if it became necessary at all—until it could be seen how the impact of the rearmament programme developed. But, the Minister continued, if it became necessary to control the engagement of labour, it would also be necessary to discuss with the employers how far their activities were to be restricted in employing workers in non-essential industries.

About restrictive practices, Mr. Bevan said that he deplored them on both sides. There was, he thought, as much "Ludditism" amongst employers to-day as there was amongst the workers. However, he had found it was no use to ask representatives of trade unions and representatives of employers to meet together for the purpose of considering the abolition of restrictive practices. That, the Minister remarked, was far too negative a form of approach and what he had asked them to do was to consider how they could concert together in order to reach optimum production.

The Minister also expressed the hope that organised labour would realise the very serious times through which the country was passing. There had been a number of unofficial strikes lately, and some more were threatened. At the moment, he said, there was in this country plenty of conciliation machinery that could be used. We had a more highly organised system of industrial conciliation than any other nation in the world, and people were only inflicting unnecessary losses upon themselves in not making use of it.

Engineering Wages

The ban on piecework and overtime imposed by workers in some engineering and shipbuilding establishments in the North of England has now continued for some weeks. It started as a protest at the piece rate clause included in the new wages agreement made last November between engineering and shipbuilding employers and the Confederation of Shipbuilding and Engineering Unions. That agreement gave an increase of 11s. a week to skilled men and 8s. a week to unskilled men on minimum time rates. Provision was made for the adjustment, where necessary, of piece rates, but many pieceworkers whose earnings are above the ceiling for the increases argue that the differentials should be amended so that their rates are increased accordingly.

At the beginning of this month the Engineering and Allied Employers' National Federation and the Confederation of Shipbuilding and Engineering Unions discussed the grievance, and agreed that negotiations could begin in the individual establishments concerned if normal working was resumed. On Monday last, leaders of the unions met the Chief Industrial Commissioner of the Ministry of Labour for a discussion of the matter. It was stated afterwards that further conversations between the employers and the Confederation of Shipbuilding and Engineering Unions would take place before the end of this week.

Employment and Unemployment

The Ministry of Labour's latest report on the employment situation in Great Britain shows that during December the working population declined by 64,000 (6000 men and 58,000 women), and at the end of that month numbered 23,205,000 (15,921,000 men and 7,304,000 women). The decrease was about the same as that which occurred at the end of 1949 and is partly explained by retirements which take place at the end of a year.

In civil employment there were 22,145,000 people at the end of December, or 97,000 less than at the end of November. Of the December total, 4,153,000 were at work in the basic industries, which showed a net decrease of 7000 during the month. In one of the basic industries—coal-mining—however, 2000 wage-earners were added to colliery books, bringing the total by the end of the month to 689,000. The manufacturing industries were employing 8,620,000 people at the end of December, which indicates a decline of 29,000 during the month in that group. The metals, engineering and vehicles trades had their labour forces reduced by 2000, and returned a total of 4,086,000, compared with 3,969,000 at the end of 1949. In Government service there were 631,000 people employed in December, an increase of 4000 during the month. That increase is attributed to a rise in the numbers employed in the defence departments.

Unemployment figures, issued last week by the Ministry of Labour, relate to January 15th, when 333,571 people were registered as out of work, compared with 301,816 on December 11th. The Ministry says that the January figure represented 1·6 per cent of the total working population. It adds that, in the week ended December 30th last, about 34,000 operatives in the manufacturing industries were on short time, losing about twenty-one hours each on the average; on the other hand, there were 838,000 people working, on an average, six and a half hours overtime.

Railway Wages

Following the publication last week of the report of the Court set up by the Minister of Labour to examine railway wage claims, two of the railway unions, the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen, expressed objection to the recommendations made. The third union—the Railway Clerks' Association—described the recommendations as unsatisfactory. The unions, it may be recalled, had each put forward claims for wage increases ranging from 7½ per cent to 15 per cent on existing rates. The Railway Executive rejected those claims, but made an alternative offer, which was to be conditional on the acceptance by the unions of alterations in working arrangements, designed to effect economy in railway operation.

That offer was rejected by the unions and the Court of Inquiry was constituted to examine the matter. It has recommended wage increases of approximately 5 per cent, and has also suggested acceptance by the unions of altered working conditions similar to those asked for by the Railway Executive. Discussions between the Railway Executive and the three unions began again last Friday, and by Monday night the unions had agreed between themselves to undertake to consider changes in working conditions if agreement was reached on their wage claims. They decided also to consider revised proposals which the Executive might make as to wages. On Tuesday evening it was stated that the Railway Executive had made a new wages offer to the three unions, and had expressed itself willing to discuss separately the matter of changes in working conditions. As these notes go to press it has been announced that talks on the new offer are proceeding between the Executive and the unions.

Since the end of last week, however, in various centres throughout the country there has been "working to rule" by some railwaymen and talk of "token strike" action as a protest against the Court's recommendations. This has occurred despite an appeal last Friday by the Minister of Labour that no action should be taken by railwaymen which might prejudice the discussions between their unions and the Railway Executive.

Notes and Memoranda

Rail and Road

BRITISH TRANSPORT COMMISSION APPOINTMENT.—The Minister of Transport announces that Mr. Frank Aubrey Pope, C.I.E., M.Inst.T., has accepted an invitation to become a full-time member of the British Transport Commission. Mr. Pope is at present chairman of the Ulster Transport Authority and the Government of Northern Ireland has been consulted.

INTERNATIONAL CONTAINER EXHIBITION.—British Railways are to exhibit six examples of their containers at the International Container Exhibition, to be held at Zurich Tiefenbrunnen Station, from April 14th to 23rd. The exhibition is being arranged by the Swiss Federal Railways on behalf of the Association of Traffic Experts of Switzerland. British Railways operate the largest number of containers of any European railway and now have some 22,000 containers of different varieties in use.

UNFINISHED ROAD SCHEMES.—In a written reply to a Parliamentary question, the Minister of Transport, Mr. Alfred Barnes, has stated that nearly £3,500,000 is tied up in sixty-seven partially-completed trunk road schemes, each costing more than £10,000, on which work was stopped owing to the war. The British Road Federation points out that the majority of these schemes were intended to eliminate notorious road hazards throughout Britain and promote a more regular flow of traffic. The most expensive project was the extension of London's Cromwell Road, costing (in 1939) £869,400. This plan was first discussed at least twenty-five years ago. Nine of the schemes affect roads in Scotland; four are in Wales and the remaining fifty-four in England. The Minister said in his reply that about £7,000,000 would be needed to complete all sixty-seven schemes.

Air and Water

DENNY GOLD MEDAL AWARD.—Mr. W. Lynn Nelson, who recently retired from the position of chief marine engineer superintendent of the Eagle Oil and Shipping Company, Ltd., has been awarded the Denny Gold Medal of the Institute of Marine Engineers for his paper entitled "Factors Governing the Design of a Modern Tanker, with special reference to Machinery."

CONFERENCE OF AIRPORT AUTHORITIES.—The second conference of Western European Airport Authorities was held recently at the Ministry of Civil Aviation, London, and was attended by representatives from the airports of Basle, Brussels, Copenhagen, Geneva, London, Paris, Schiphol and Zurich. An observer from New York airport was also present. The conference discussed procedures affecting the development and operation of international airports and, in particular, means of reducing the serious operating deficits which most airports incur.

GENERATING STATION AT TOBERMORY.—Under the North of Scotland Hydro-Electric Board's constructional scheme No. 57, which has been approved by the Secretary of State for Scotland and laid before Parliament, the former Ledaig distillery building at Tobermory is now to be used as a generating station to deal with the growing demand for electricity in Mull. The existing small hydro-electric scheme on the Tobermory River will be extended and hydro-electric and diesel plant with a combined capacity of 1MW will be installed in the new generating station. The scheme is estimated to cost £92,000.

DUTCH SHIPYARD ANNIVERSARY.—On the seventy-fifth anniversary of the founding of the N.V. Koninklijke Maatschappij "De Schelde," in Flushing, the company has published a survey of its history. This takes the form of a pictorial record, which covers the wide range of activities over the years. When the firm began in 1875 the staff numbered eighteen. This has grown to over 4000 and the modest yard, which started by building fishing vessels, has expanded in size so that it can now build ocean liners, such as the "Willem Ruys." Reproductions of old prints depict early shipbuilding at Flushing and subsequent photographs contrast the old with the new. Illustrations show early naval vessels and those of more recent date; cargo boats built at the turn of the century and modern cargo liners, diesel engines and turbine machinery under construction; early triple expansion engines, bridge building and activities in connection with bus construction and the building of aircraft. The brochure begins with a brief account of the development of the shipyard. This is translated into English, French and Spanish and all the photographs have their captions similarly translated.

Miscellanea

NARROW MINES DIESEL LOCOMOTIVES.—Three new 100 h.p. mines type diesel locomotives, supplied to the Brandon Colliery in Co. Durham, by the Hunslet Engine Company, Ltd., each have an overall width of 3ft 11in for a 2ft 6in gauge. These locomotives retain the integral cast type of frame used in the standard Hunslet 100 b.h.p. and 65 b.h.p. locomotives, and also the integral sub-assembly of Westinghouse air-brake and sanding gear. In working order the new locomotives each weigh 15 tons and they have four track speeds, of 3·75, 6·15, 9·35 and 14·6 m.p.h. Their maximum height is 5ft 4in, with a wheelbase of 5ft 3in. Neither the length over couplers or the throw-over on curves are greater than those of the existing standard 100 h.p. model mines locomotives made by the company.

NATIONAL SMOKE ABATEMENT SOCIETY.—The National Smoke Abatement Society has published, in booklet form, the proceedings at its annual conference at Margate last year. As well as the complete text of the papers presented at the conference, the booklet contains the Des Vœux memorial lecture, "Towards the Better Use of Coal,", which was delivered by Dr. D. T. A. Townend, director-general of the British Coal Utilisation Research Association.

BIRMINGHAM FIRM'S JUBILEE.—Rapid Magnetic Machines, Ltd., Lombard Street, Birmingham, has just celebrated its golden jubilee. When the firm was founded in 1901 it introduced a drum separator, carrying a yoke of electromagnets for extracting ferrous from non-ferrous metals in scrap yards. Now the company manufactures a wide range of magnetic separating and lifting equipment. At a jubilee dinner, special awards were presented to employees with twenty-five or more years' service.

FREIGHT TRANSITS BY "GREEN ARROW" SERVICE.—British Railways propose to restore on March 1, 1951, the "Green Arrow" registered transits service for full wagon loads of freight traffic for export, except traffic to Ireland. Under this scheme a full consignment of goods can be registered through to the port, every railway contact point *en route* receiving an advance advice, by telephone or telegraph, of the consignment's passage. A constant watch is maintained until the goods are finally delivered, and the sender can also ascertain in advance when delivery can be effected.

NICKEL CHROMIUM ALLOYS.—The "Nimonic" series of alloys forms the subject of an article in the current issue (No. 11, vol. 23) of the *Nickel Bulletin*, published by the Mond Nickel Company, Ltd., Sunderland House, Curzon Street, London, W.1. The article contains useful tabular data about the "Nimonic" alloys available, the specifications to which they are produced and their physical and mechanical properties, including their tensile and creep characteristics. Illustrations showing examples of turbine blading, stator blades and creep characteristics are included in the article.

POWER STATION EXTENSIONS AT DRAKELOW AND HACKNEY.—The British Electricity Authority has received the consent of the Minister of Fuel and Power to extensions of the new power station now under construction at Drakelow, in the East Midlands Division, and of the existing power station at Hackney, London. The authorisations provide for the installation at Drakelow of two further 60MW turbo-alternator sets and two boilers, each of an evaporative capacity of 515,000 lb of steam per hour and the installation at Hackney of two 30MW turbo-alternator sets, two boilers, each of an evaporative capacity of 300,000 lb per hour, and one cooling tower with a capacity of 2·25 million gallons of water per hour.

PRODUCTIVITY IN THE MOTOR CONTROL GEAR AND ALLIED INDUSTRIES.—An open meeting will be held at the Connaught Rooms, Great Queen Street, Kingsway, London, W.C.2, on Tuesday, February 27, 1951, at 2.30 p.m., to give an opportunity for those concerned with production and allied problems (in motor control gear and small air-break switchgear) to meet members of the productivity team which visited the U.S.A. in 1950. Mr. E. C. Holroyde (Vice-Chairman and Director of Crompton Parkinson, Ltd.) will preside at the meeting; the productivity team's report will be presented by Mr. J. R. Walton (Managing Director, Electrical Apparatus Company, Ltd.), the leader of the team, and will then be open to discussion. Further information and copies of the productivity team's report (price 2s., post free) can be obtained from the British Electrical and Allied Manufacturers' Association (Inc.), 36, Kingsway, London, W.C.2.

Personal and Business

MR. EDWARD H. JEFFERSON has been appointed a director of Hawker Aircraft, Ltd.

MR. F. J. WELCH has been appointed to the sales promotion department of C.A.V., Ltd., Acton, London, W.3.

MR. E. A. W. HORNETT has been appointed secretary of the British Internal Combustion Engine Manufacturers' Association.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that the telephone number of its Norwich branch has been changed to Norwich 21526.

MR. D. N. WALKER, M.I.Mech.E., has been appointed chief mechanical engineer at the London headquarters of the National Coal Board, Hobart House, Grosvenor Place, S.W.1.

MR. P. J. C. BOVILL, director of the local board and general manager of the chemical works of Newton Chambers and Co., Ltd., has been appointed chairman of the Sheffield Centre of the Institute of Industrial Administration.

GLOSTER AIRCRAFT COMPANY, Ltd., states that it has completed negotiations with Fairey Aviation, Ltd., to set up a production line at the Avion Fairey Works, Gosselies, Belgium, in order to expedite deliveries of "Meteor VIII" jet aircraft to the Belgian Air Force.

BROOKHIRST SWITCHGEAR, Ltd., Chester, has opened a district office at Lloyds Bank Chambers, 15, Sandhill, Quayside, Newcastle-upon-Tyne, 1. Mr. T. G. Evans has been appointed district manager with responsibility for the company's interests in Northumberland and Durham.

MR. J. H. GIBSON, director and chief engineer of Dewrance and Co., Ltd., is leaving for Australia to-day. His headquarters during his six weeks' stay will be c/o. The Austral Engineering Supplies Pty., Ltd., 490–492, Kent Street, Sydney. Mr. Gibson proposes to return to this country via the U.S.A.

Catalogues

SAMUEL FOX AND CO., Ltd., 17, Westbourne Road, Sheffield, 10.—Illustrated publication giving easy reference to steel qualities and specifications.

HACKBRIDGE AND HEWITTIC ELECTRIC COMPANY, Ltd., Hersham, Walton-on-Thames, Surrey.—Leaflet No. 235, dealing with vehicle battery chargers.

SANDERSON BROTHERS AND NEWBOULD, Ltd., Attercliffe Steel Works, Newhall Road, Sheffield.—Catalogue of "'Sabenite' Tungsten Carbide Tipped Tools."

ROM RIVER COMPANY, Ltd., 3–16, Woburn Place, London, W.C.1.—Brochure describing the four aspects of reinforcement service—design, supply, bending, fixing.

STURTEVANT ENGINEERING COMPANY, Ltd., Southern House, Cannon Street, London, E.C.4.—Publication No. 9602, dealing with Sturtevant laboratory machinery.

DAVEY, PAXMAN AND CO., Ltd., Colchester.—Publication No. 1261, illustrating and describing "'RPHL' and 'RPHXL' Engines: Series I and II for Rail Traction."

LAPOINTE MACHINE TOOL COMPANY, Ltd., Edgware, Middlesex.—Bulletin No. F 132 (B), describing the V-type range of general-purpose hydraulic pull-down broaching machines.

RAWLPLUG COMPANY, Ltd., Rawlplug House, Cromwell Road, London, S.W.7.—Catalogue listing all diameters, lengths and prices of "Rawlplugs" and "Rawlbolts."

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Loughborough.—Publication No. 11,091, giving particulars of the widened range of Brush fractional horse-power motors.

ERNEST NEWELL AND CO., Ltd., Misterton, via Doncaster.—Publication entitled "Typical Installations," describing different types of plant built during the past ten years.

RENOLD AND COVENTRY CHAIN COMPANY, Ltd., 28, Deansgate, Manchester, 3.—Leaflet entitled "Renold Chains in Agriculture," illustrating some applications to mechanised farming.

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Loughborough.—Publication No. 23,061, featuring "Salient Pole Alternators (Type 'OTS') with Outputs from 40kVA to 250kVA.

HILGER AND WATTS, Ltd., 98, St. Pancras Way, Camden Road, London, N.W.1.—Leaflets describing the "Spekker Ultra-Violet Photometer," and "Watts Microptic Colorimeter."

FRY'S METAL FOUNDRIES, Ltd., Tandem Works, Merton Abbey, London, S.W.19.—Leaflet No. 6, giving reference data on solders and fluxes; Booklet No. 22, describing "Fryolux" solder paint.

BOUND BROOK BEARINGS (G.B.), Ltd., Trent Valley Trading Estate, Trent Valley Road, Lichfield, Staffs.—Leaflet dealing with Compo oil-retaining bearings, entitled "A Triumph of Powder Metallurgy."

British Patent Specifications

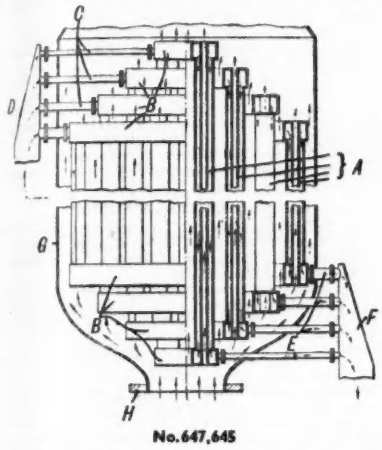
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

HEAT EXCHANGERS

647,645. May 22, 1947.—Improvements in or relating to Heat Exchangers, Meyer Schlioma Frenkel, 19, Paget Road, London, N.16.

This invention relates to all kinds of heat exchangers as used in the chemical industry, refrigeration, condensers, evaporators and the like. Shown in the sectional elevation are four coaxial cylindrical rows of double tubes *A* between annular header tanks *B*. The central row of tubes of the smallest diameter is the longest, the lengths



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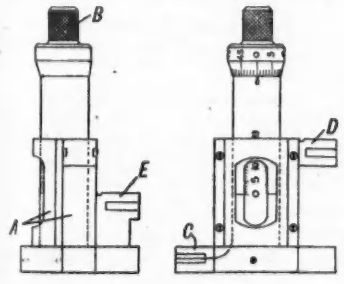
of the other rows decreasing step by step with increasing diameter to allow the fluid flowing outside the tubes access from one side to the ends of the tubes in each row where they join their header tanks. A high-pressure fluid which, say, is to be cooled, enters the top annular header tanks through their induction pipes *C* and from entry duct *D*. These induction pipes have different diameters as is required for the different volumes of fluid having to flow in unit time through the different tube rings. The high-pressure fluid, after having flowed downwards through its annular spaces and had its heat exchange, is then collected in the lower header tanks, from where it flows away through the pipes *E* to exit duct *F*. The second fluid taking part in the heat exchange enters at the bottom of the casing *G*, which surrounds the tube bundle, through the flanged entry *H*. Its upward flow in an axial direction between the header tanks ensures an equal flow of fluid over all the tubes.—*December* 20, 1950.

TOOLS AND WORKSHOP APPLIANCES

649,231. November 19, 1948.—Improvements in or relating to Precision Height Gauges, Ejler Holch, 28, Tulipanvej, Copenhagen, Denmark.

The invention relates to a precision height gauge with a micrometer screw, principally intended to replace the adjustable gauge blocks ordinarily employed nowadays in machine shops. The slide



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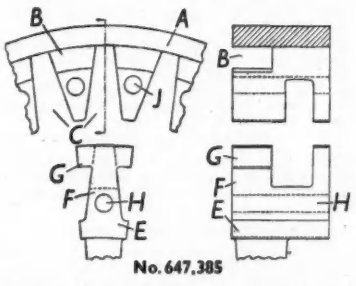
A, with its measuring scale, on the micrometer screw *B* is provided with three laterally projecting measuring arms, two, *C* and *D*, extending in opposite directions and the third *E* at right angles to them. The flat top faces of the arms define planes separated by at a distance equal to the total travel potential of the slide. The gauge therefore has three different ranges of measurement in continuation of one another, and uses a slide with a travel of only one-third of the total range of measurement. Various uses of the gauge are illustrated in the specification with and without a base extension. The case of the gauge has laterally projecting toes beneath each of the three measuring arms.—*January* 24, 1951.

GAS TURBINES

647,385. October 5, 1948.—Improvements in and relating to Elastic Fluid Turbines, The English Electric Company, Ltd., of Queens House, 28, Kingsway, London, W.C.2 (*Inventor, Adolf Frankel*).

The invention relates to the fixture of stator blades particularly in gas turbines, where a problem arises of providing a blade roots fixture which is not adversely affected by thermal expansion of the blades and their supporting ring and which is easy to manufacture and to assemble or dismantle. The drawings show a partial front elevation of a blade-retaining ring and a side elevation in section. The blade-retaining ring *A* has in its front face a circular groove *B*, and in its inner section trapezium-shaped slots *C* extending right through in an axial direction. The blade has the usual platform *E*, the outer



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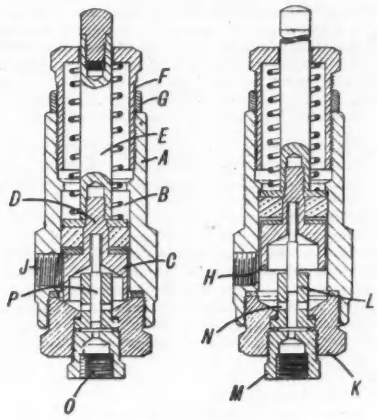
radius of which matches the inner radius of the ring *A*, and has wedge-shaped roots *F* adapted to match the trapezium-shaped slots of the ring. The roots are provided with lateral lugs *G* extending axially from the front face of the blade to the depth of the annular groove *B* in front face of the ring. The outer radius of the lugs *G* matches the outer radius of groove *B* and the inner radius matches the inner radius of the groove. The wedge-shaped roots may be provided near their broader base with a bore *H* in order to narrow the path available to heat conduction from the blade to the retaining ring, while similarly between the trapezium-shaped slots bores *J* may be provided. The design of the blade-retaining ring makes it possible to use straightforward turning for the groove, and slotting or milling for the slots. An alternative arrangement described in the specification makes use of involute curves instead of straight faces formed by a method similar to that for producing internal toothed gearing.—*December* 13, 1950.

MISCELLANEOUS

649,014. July 7, 1948.—Improvements in or relating to Pressure Relief Valves, Uni-Gun Lubricating Equipment, Ltd., 2, South Audley Street, Mayfair, London, W.1, and Ivan Charles Martonfalvy, of the company's address.

The drawings show the valve in open and closed positions. The valve comprises a cylindrical body *A* having a bore *B* in which a piston *C* can reciprocate. The piston is provided on one side with a stem *D* encircled by a packing washer and the stem is screwed on the end of a spindle *E*. The casing *A* has at one extremity a hollow plug *F*. The loading of a compression spring between the ends of the hollow plug member and the washer can be varied, and a lock nut *G* holds the plug in the desired position. The spindle extends out through the top of the plug and serves as an indicating device for determining the position of the piston. The piston is provided with a skirt *H* which, when the device is not subjected to pressure, covers an exhaust port *J* in the side wall of the cylinder casing. The piston skirt is slightly smaller in diameter than the bore *B*. The port *J* is coupled to a conduit leading back to the low pressure side of the pump. In the lower threaded portion of the casing *A* is a plug *K*, having an inner concave conical surface. A small cylinder *L* through the plug bore has an enlarged head, which rests against a shoulder and is held in position by a hollow plug *M*. The small cylinder is provided with valve ports *N* opposite the conical surface. In the plug *M* is a threaded passage *O* leading to a port opposite the end of the bore in the small cylinder *L*. The passage *O* is coupled to a conduit communicating with the high-pressure side of the lubricating pump. Mounted in the bore of the cylinder *L* is a plunger *P* having a reduced extremity which fits loosely in a hole in the piston *C*. The arrangement is such that when the pressure beneath the plunger *P* is sufficient to raise the end

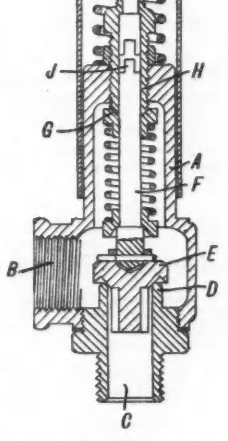


No. 649,014

of the plunger past the valve port *N*, against the action of the spring, the piston *C* is then subjected to pressure and being of a larger area will immediately further compress the spring and uncover the port *J*, through which the lubricant will escape to the low-pressure side of the pumping system. When the pressure falls sufficiently below the pressure which initially moves the plunger *P* the spring will move the piston plunger downwards, first cutting off the valve ports *N*. The plunger continues to descend, during which time oil will pass through the gap and out through the port *J* until finally the port is closed by the plunger. —*January* 17, 1951.

649,275. February 6, 1948.—Improvements in or relating to Spring-Loaded Valves, Bacterol, Ltd., and George Edward Favero, both of 435, Strand, London, W.C.2.

The valve body illustrated comprises a tubular portion *A* formed at its lower end with a threaded opening *B* for an outlet pipe. The lower end of the body has a threaded opening in which is screwed an inlet union *C* with a conical seat *D*. Engaged with the conical seat is a plunger *E* having a corresponding conical face and connected by means of a split pin to a valve stem *F* with a collar upon which seats the lower end of a coiled compression



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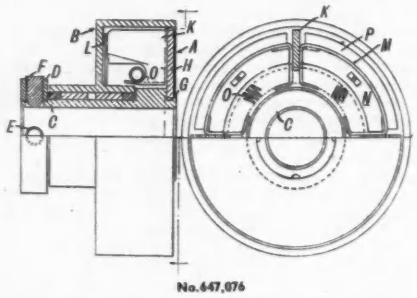
spring. The upper end of the spring abuts against a similar collar slidable on the stem and having on its upper surface a conical recess *G*, to engage the lower coned end of a sleeve *H*, which is screwed through a threaded opening in the top of the valve housing and locked in a set position by a lock nut. A dog *J* on the upper end of the valve stem engages in a rotatable key *K*, which extends out of the top of the sleeve through a gland. Fitted over the upper end of this key is a sleeve *L*, which at its lower end is a sliding fit

over the body of the valve. The sleeve is secured to the key *K* by a nut and the sleeve is movable downwards to engage the key *K* with the valve stem against the influence of a coiled compression spring. The sleeve also acts to protect the upper spring from dirt and affords a good gripping surface for the hand of the operator when carrying out the surface cleaning of the valve seating *D*. When the sleeve is depressed it can easily be turned to effect cleaning and when released the upper compression spring elevates the sleeve and disengages the key from the valve stem. During the cleaning the spring loading of the valve *E* maintains the valve in contact with its seating *D*.—*January* 24, 1951.

647,076. January 23, 1948.—IMPROVEMENTS IN CENTRIFUGAL CLUTCHES, The Centric Clutch Company, of 22–26, South Avenue, West Cranford, New Jersey, U.S.A.

The invention pertains to a centrifugal clutch which is so arranged as to have a very gradual engaging action and to render the centrifugal force exerted capable of adjustment. Referring to the drawing the clutch comprises a driving member *A* and a driven member *B*. The driving member comprises a sleeve *C* mounted on a driving shaft having a collar *D* fixed by the setscrew *E*. The collar is also provided with a setscrew *F* which extends through the sleeve and bears against the shaft. The sleeve at its opposite end is provided with a shoulder *G*, fixed to which is a rotor member *H*. The rotor member comprises a disc from which vanes *K* are bent off. The vanes extend axially to the driving member *A* and are joined by an annular ring *L*. The rotor has four vanes and, correspondingly, there are provided four centrifugally operating elements *M*, made of sheet metal bent into arcuate form. In order that



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the amount of centrifugal force exerted by the elements may be changed, weights *N* are provided. In operation, the member *H* is driven and its vanes bear against and drive the members *M*. As the speed of the driving member increases, centrifugal force proportionate to the weights is exerted, and the group of centrifugally operating members, comprising the arcuate band with the weights and the friction shoe, move radially outwards, overcoming the tension of the spring *O* at a speed depending upon the strength of the spring as well as upon the mass of the weights. The shoes *P* contact the inner annular surface of the driven member *B*. This member, which is rotatable on the sleeve *C*, is fitted with a hub in which is secured a bush. Thus, at a speed adjusted by varying the number of weights, the driving member engages the driven member, the engaging action being gradual, since the centrifugal force exerted by the weights has to overcome the tension of the spring. The clutch is made substantially from stamped metal parts and can be economically manufactured. —*December* 6, 1950.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Thurs., Mar. 1*st.*—S. LONDON BRANCH: Café Royal, North End, Croydon, "Electric Telemetering," L. James, 8 p.m.

British Institution of Radio Engineers

Thurs., Mar. 1*st.*—N.W. SECTION: College of Technology, Manchester, "A Survey of Television Development and its Problems," H. J. Barton-Chapple, 7.15 p.m.——MERSEYSIDE SECTION: Electricity Service Centre, Whitechapel, Liverpool, "The Use of Foster's Theorem in Circuit Design," E. Williams, 7 p.m.

Illuminating Engineering Society

Wed., Feb. 28*th.*—Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, discussion, "Assessment of Lighting: Instruments or Instinct," opened by H. G. Campbell and W. R. Stevens, 6 p.m.

Thurs., Mar. 1*st.*—EXETER GROUP: Agricultural House, Queen Street, Exeter, "Illumination and Illusion," P. Hartill, 7 p.m.

Fri., Mar. 2*nd.*—BATH AND BRISTOL CENTRE: S.W. Electricity Board Showrooms, Bath, "Illumination and Illusion," P. Hartill, 7 p.m.

Incorporated Plant Engineers

Mon., Feb. 26*th.*—W. AND E. YORKSHIRE BRANCH: Mining Department Lecture Theatre, The University, Leeds, "Mechanical Handling," 7.30 p.m.

Thurs., Mar. 1*st.*—PETERBOROUGH BRANCH: Eastern Gas Board's Demonstration Theatre, Church Street, Peterborough, Film and Lecture, "Discharge Lighting," 7.30 p.m.

Institute of British Foundrymen

Sat., Feb. 24*th.*—BRISTOL AND WEST OF ENGLAND BRANCH: Grand Hotel, Broad Street, Bristol, "The Development of Foundry Sand Control," G. L. Harbach, 3 p.m.——E. MIDLANDS BRANCH: School of Arts and Crafts, Green Lane, Derby, "Refractory Materials in Use," A. T. Green, 6 p.m.——WALES AND MONMOUTH BRANCH: Engineers' Institute, Cardiff, "Non-Ferrous Foundry Practice," J. Bamford, 6 p.m.

Wed., Feb. 28*th.*—BIRMINGHAM BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "Grain Refinement and its Effects in Cast Non-Ferrous Metals," A. Cibula, 7.15 p.m.——LONDON BRANCH: Waldorf Hotel, Aldwych, W.C.2, "Valve Guide Castings," Rene Dulche, 7.30 p.m.

Institute of Industrial Supervisors

To-day, Feb. 23*rd.*—CARDIFF SECTION: Technical College, Cardiff, "The Foreman and Productivity," B. H. Dyson, 7 p.m.

Tues., Feb. 27*th.*—DUDLEY AND DISTRICT SECTION: Technical College, Dudley, "Modern Foundry Practice," W. Barnes, 7.30 p.m.

Thurs., Mar. 1*st.*—WARRINGTON SECTION: White Hart Hotel, Sankey Street, Warrington, "The Foreman and Motion Study," N. G. Moss, 7 p.m.

Institute of Refrigeration

Tues., Feb. 27*th.*—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, "The Practice of Refrigerator Lubrication," S. J. M. Auld and H. M. Davies, 5.30 p.m.

Institution of Chemical Engineers

Sat., Feb. 24*th.*—MIDLAND BRANCH: The University, Edmund Street, Birmingham, "The Behaviour of Gas Bubbles in Relation to Mass Transfer," C. T. Meiklejohn and P. D. Coppock, 3 p.m.

Institution of Civil Engineers

Tues., Feb. 27*th.*—Great George Street, Westminster, S.W.1, "Engineering Factors Influencing the Adoption of Rigid and Flexible Pavements," B. H. Knight; "Testing Runway Foundations and Pavements," J. A. Skinner, 5.30 p.m.

Institution of Electrical Engineers

Mon., Feb. 26*th.*—N.E. CENTRE: Neville Hall, Westgate Road, Newcastle-upon-Tyne, "Transients in Electric Mine Winders and Their Effects on Rope Stresses," T. H. Petch, 6.15 p.m.

Tues., Feb. 27*th.*—MEASUREMENTS SECTION: Savoy Place, Victoria Embankment, W.C.2, discussion on "Electrical Measurement by Thermal Effects," opened by J. Greig, L. G. A. Sims and J. G. Freeman, 5.30 p.m.——SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Some Electrical Methods of Measuring Mechanical Quantities," F. J. Woodcock, 7 p.m.

Thurs., Mar. 1*st.*—Savoy Place, Victoria Embankment, W.C.2, "The London-Birmingham Television Radio-Relay Link," R. J. Clayton, D. C. Espley, G. W. S. Griffiths and J. M. C. Pinkham, 5.30 p.m.

Fri., Mar. 2*nd.*—N.E. STUDENTS' SECTION: King's College, Newcastle-upon-Tyne, "The Schlieren System," B. Berger, 6.30 p.m.

Institution of Engineering Inspection

Wed., Feb. 28*th.*—WEST OF SCOTLAND BRANCH: Engineering Centre, 351, Sauchiehall Street, Glasgow, "Time Study Incentive Systems," J. MacGregor, 7.30 p.m.

Thurs., Mar. 1*st.*—LONDON CENTRE: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Inspection in Heavy Engineering," M. A. Fiennes, 6 p.m.

Institution of Heating and Ventilating Engineers

To-day, Feb. 23*rd.*—MANCHESTER AND DISTRICT BRANCH: Town Hall, Manchester, Chairman's Address, 6.30 p.m.

Tues., Feb. 27*th.*—SCOTTISH BRANCH: Engineering Centre, 351, Sauchiehall Street, Glasgow, "Water Treatment," J. S. Couper, 6.30 p.m.

Institution of Mechanical Engineers

To-day, Feb. 23*rd.*—Storey's Gate, St. James's Park, S.W.1, discussion on "Fatigue Tests," 5.30 p.m.

Sat., Feb. 24*th.*—MIDLAND BRANCH, GRADUATES' SECTION: Visit to Ansells Brewery, Birmingham, 10 a.m.——N.E. BRANCH, GRADUATES' SECTION: Northern Gas Board Showrooms, Grainger Street, Newcastle-upon-Tyne, annual general meeting, "Some Comments on Power Station Lay-out," L. Sproat, 2.30 p.m.

Tues., Feb. 27*th.*—N.W. BRANCH, GRADUATES' SECTION: Engineers' Club, Albert Square, Manchester, "Production Control," B. Booth, 6.45 p.m.——BIRMINGHAM A.D. CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, annual general meeting, "The Development of the De Havilland Series of Light Aircraft Engines," J. L. P. Brodie, 6.45 p.m.

Wed., Feb. 28*th.*—SOUTHERN BRANCH, GRADUATES' SECTION: University College, Southampton, "Radiography in Industry," K. U. Taylor, 7 p.m.——YORKSHIRE BRANCH: The University, Sheffield, "Simplification Creates New Problems for Top Management," H. E. Merritt, 7 p.m.——N.W. A.D. CENTRE: Engineers' Club, Albert Square, Manchester, annual general meeting, film display, 7 p.m.

Thurs., Mar. 1*st.*—SCOTTISH BRANCH, GRADUATES' SECTION: Royal Technical College, Glasgow, annual general meeting, Chairman's Address, "Natural Circulation in Water-Tube Boilers."

Fri., Mar. 2*nd.*—Storey's Gate, St. James's Park, S.W.1, "The Training of Engineers for the Chemical Industry," W. F. Carey, 5.30 p.m.——N.E. BRANCH, GRADUATES' SECTION: King's College, Newcastle-upon-Tyne, "The Schlieren System" B. Berger, 6.30 p.m.

Institution of Production Engineers

Sat., Feb. 24*th.*—N.E. SECTION: Visit to Pyrotenax, Ltd., Hedgeley Road, Hebburn, Co. Durham, 10 a.m.

Sun., Feb. 25*th.*—S. WALES AND MONMOUTHSHIRE SECTION: S. Wales Institute of Engineers, Park Place, Cardiff, "Fundamentals of Production Management," M. Seaman, 6.45 p.m.

Tues., Feb. 27*th.*—LUTON SECTION: Town Hall, Luton, "The Control of Quality in Large and Medium-Quantity Production," J. Loxham, 7.15 p.m.

Wed., Feb. 28*th.*—COVENTRY GRADUATE SECTION: Technical College, Coventry, "Industrial Tool Rooms," C. Kingham, 7.15 p.m.——LINCOLN SECTION: visit to Clayton Dewandre and Co., Ltd., Lincoln, 6 p.m.——WESTERN SECTION: Westinghouse Brake and Signal Company, Ltd., Chippenham, "Productivity," E. C. Gordon England, 7.30 p.m.

Thurs., Mar. 1*st.*—GLASGOW SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, annual general meeting, graduates' open discussion night, 7.30 p.m.——LONDON SECTION: Powers-Samas Accounting Machines, Ltd., Aurelia Road, Mitcham Road, Croydon, "A Broader Conception of Productivity and its Measurement," F. G. S. English, 7 p.m.

Fri., Mar. 2*nd.*—W. WALES SUB-SECTION: Central Library, Alexandra Road, Swansea, "Social Function of Industry," A. Roberts, 7.30 p.m.

Institution of Structural Engineers

To-day, Feb. 23*rd.*—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "Distribution Methods of Structural Analysis," A. J. Francis, 6 p.m.

Fri., Mar. 2*nd.*—WESTERN COUNTIES BRANCH: College of Technology, Bristol, "Light-Gauge Structural Steel Sections," F. W. L. Heathcote and A. H. Chilver, 6.15 p.m.

Institution of Works Managers

Mon., Feb. 26*th.*—GLASGOW BRANCH: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Producing What We Can Sell—Selling What We Can Produce," 7.15 p.m.

Thurs., Mar. 1*st.*—BRISTOL SECTION: Royal Hotel, Bristol, "Maintenance," B. E. Dovey, 7.15 p.m.

Fri., Mar. 2*nd.*—NOTTS AND DERBY BRANCH: Midland Hotel, Derby, "Is Management an Art or a Science?" J. Ayres, 7.30 p.m.

Junior Institution of Engineers

To-day, Feb. 23*rd.*—39, Victoria Street, London, S.W.1, "Sundials," Laurence H. A. Carr, 6.30 p.m.——SHEFFIELD AND DISTRICT SECTION: Grand Hotel, Sheffield, "Some Recent Examples of Centralised Lubrication Systems," S. J. Norton, 7.30 p.m.

Sat., Feb. 24*th.*—N.W. SECTION: Geographical Society, 16, St. Mary's Parsonage, Manchester, "Mechanical Stokers," C. Kenyon, 2.30 p.m.

Fri., Mar. 2*nd.*—39, Victoria Street, S.W.1, films on "Foundry Practice," introduced by A. S. Ladley, 6.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, Feb. 23*rd.*—Neville Hall, Westgate Road, Newcastle-upon-Tyne, "A Comprehensive Series of Vibration Tests on the S.S. 'Clan Alpine' and the S.S. 'Ocean Vulcan,'" A. J. Johnson, 6.15 p.m.

Royal Aeronautical Society

To-day, Feb. 23*rd.*—Institution of Civil Engineers, Great George Street, S.W.1, "Power versus Weight in Aviation," M. Roy, 6 p.m.

Tues., Feb. 27*th.*—4, Hamilton Place, London, W.1, "Development in Aircraft Wheels, Tyres and Brakes," J. Wright, 7 p.m.

Thurs., Mar. 1*st.*—Institution of Civil Engineers, Great George Street, Westminster, S.W.1, "Progress Towards Electrical Serviceability," R. H. Woodall and W. A. Higgs, 6 p.m.

Royal Society of Arts

Wed., Feb. 28*th.*—John Adam Street, Adelphi, W.C.2, "1851–1951: A Century of British Engineering," W. T. O'Dea, 2.30 p.m.

Society of Instrument Technology

Tues., Feb. 27*th.*—Manson House, Portland Place, W.1, "The Measurement of Surface Temperature," R. C. Parker, 7 p.m.

Stephenson Locomotive Society

Sat., Feb. 24*th.*—SCOTTISH CENTRE: 302, Buchanan Street, Glasgow, annual general meeting, 3 p.m.——N.W. AREA: Geographical Society's Rooms, Deansgate, Manchester, "The Belfast and County Down Railway," R. E. Trimble, 6.15 p.m.

UNIVERSITY LECTURES ON H.V. TRANSMISSION.—A course of four lectures on "The Problems of Power Transmission at Voltages above 220kV" will be given by François Cahen, of Electricité de France, at the Senate House, University of London, W.C.1. The lectures will be on March 1st (6 p.m.) and March 2nd, 5th and 6th (5.30 p.m.), admission being free, without ticket. Sir John Hacking, Deputy Chairman (Operations), British Electricity Authority, will take the chair at the first lecture.